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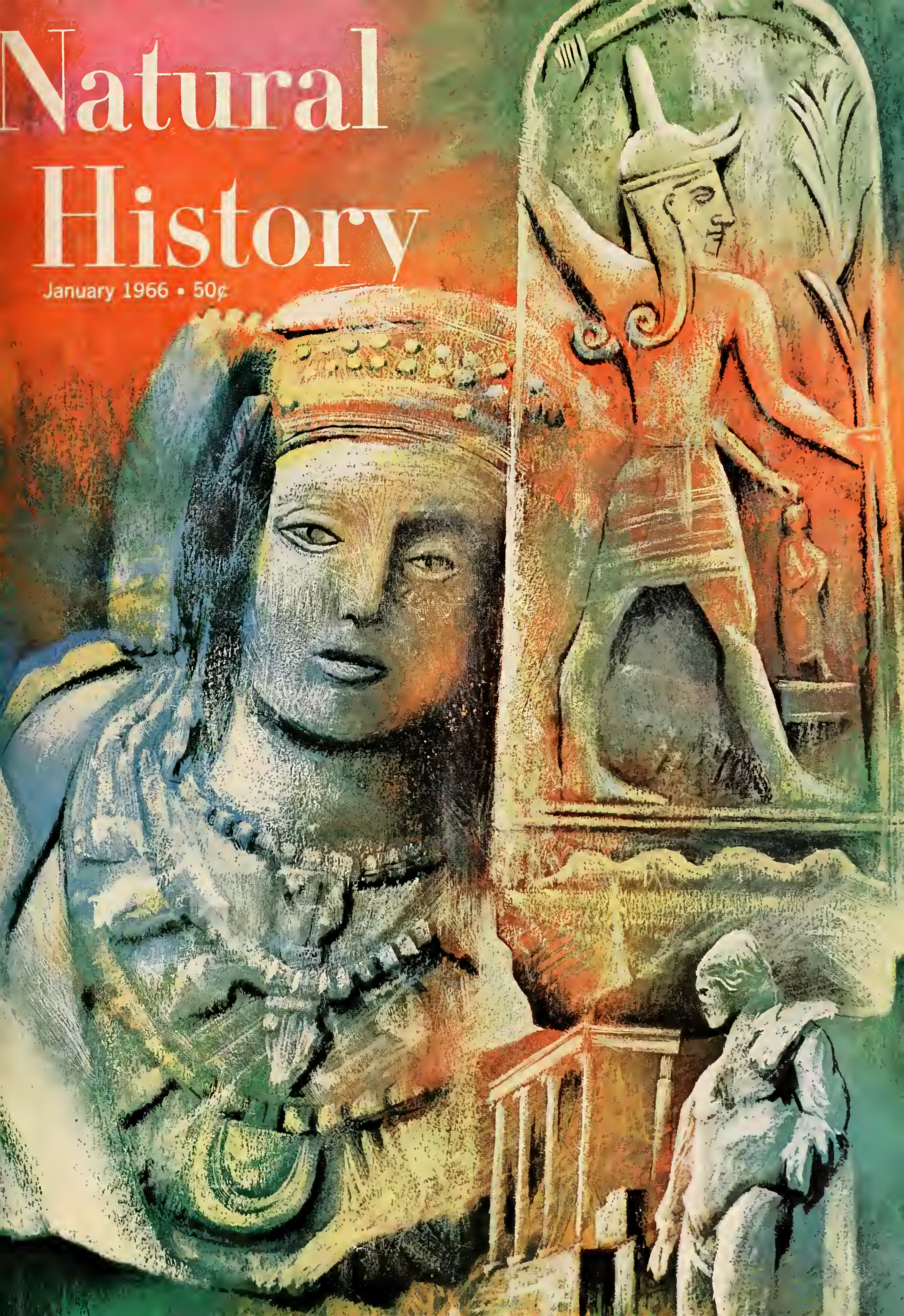

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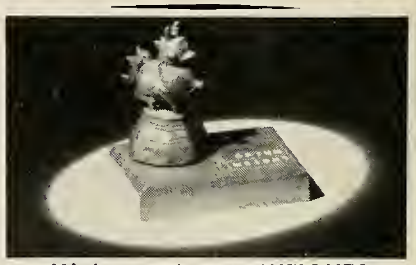

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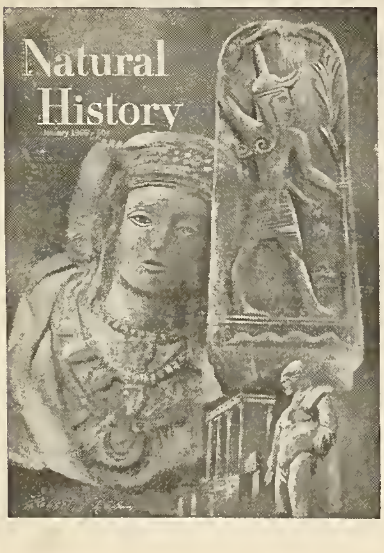

Natural History

Incorporating Nature Magazine

THE JOURNAL OF THE AMERICAN MUSEUM OF NATURAL HISTOR

Vol. LXXV — JANUARY 1966 — No.

ARTICLES

DEPARTMENTS

COVER: The Lady of Elche, at left, the finest of all Phoenician sculptures came from the Iberian-Punic area at the western end of the Mediterranean, an is relatively recent. At her right is a stela showing the god Baal with mace an sprouting spear shaft, symbolic of war and fertility. This early piece was foun at Ugarit, in the easternmost portion of the Phoenicians' Mediterranean world At the lower right is a statue from the Theatre at Leptis Magna, a Punic city Who were these powerful, far-ranging seagoers? Dr. Cyrus H. Gordon tell of their origins and broad influences in an article that begins on page 14

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Life in an alien culture

By Hobart M. Van Deusen

PATROL INTO YESTERDAY, by J. K. McCarthy. *F. W. Cheshire, Ltd. (Melbourne), $5.32; 252 pp., illus.* THE HIGH VALLEY, by Kenneth E. Read. *Charles Scribner's Sons, $6.95; 266 pp., illus.* DOCTOR'S WIFE IN NEW GUINEA, by Margaret Spencer. *Angus & Robertson, Ltd. (London), $2.50; 189 pp., illus.* DOCTOR'S WIFE IN PAPUA, by Margaret Spencer. *Robert Hale, Ltd. (London), $ 2.63; 176 pp., illus.*

THESE four books on personal experiences in New Guinea have much in common. Director of Native Affairs Keith McCarthy, doctor's wife Margaret Spencer, and anthropologist Kenneth Read have written highly subjective accounts of their years on this rugged island, peopled by some of the most primitive tribes the world has known. Frankly personal books on life in an alien culture, as boiled down from a multiplicity of experience, have all the variety of old-fashioned quilts—no two are alike. All four of these books, however, stand on common ground, because each author is a student of human ecology. It is this active interest in the relationship of man to his environment within a frame of Stone Age culture that makes each book such enjoyable reading. There is a satisfying strength to publications that result from years of firsthand experience, because objectivity comes with reflection and interest born of a sincere attempt to bridge cultural patterns with understanding. Today, more than ever before, the world is faced with bringing true understanding to the problems of emerging peoples. After a thoughtful reading of these books, every interested reader will attain a degree of insight into the problems facing the people of New Guinea and the Australian administration.

In 1927, twenty-two-year-old Cadet Patrol Officer Keith McCarthy went to New Guinea with the admonition of his father: "For God's sake, son, don't get eaten by the natives. I'd never live it down at the Celtic Club."

McCarthy never was eaten, and in forty years of field and administrative work he survived not only stone clubs and showers of arrows but also the advice of a "friend" to "Be a sound Government official, my boy. . . . Stop trying to do things. Just write and talk about 'em!" But McCarthy and other officers *have* "done things" for the good of the natives and for the country that will one day be governed by them. It will be to the everlasting credit of the Australian administration that men of McCarthy's caliber were chosen to interpret the outside world of civilization to these amazing survivors of the Stone Age. If *Patrol Into Yesterday* were the mere recital of these early adventures, it would be well worth reading, but the author is a thinking man, as well. His words should be on the walls of every Foreign Office: "The cry throughout the world today is self-government; and it is Australia's aim to bring the people of New Guinea to self-government; but it has set no target dates, for there are many problems yet . . . poor economy, the lack of national unity, and the shortage of men who can adequately staff the Public Service. . . . Why advance a people to political independence when you know very well they can't afford it? . . . the answer came to me from experience: 'It is impossible to educate a man along a single line.' Political education is not an alternative course to economic and social advancement—it is complementary to the other two. Political education is part of a general education, and the political aims which develop cannot be retarded to keep pace with the economic growth of the country, and we have no option but to accept this in the case of New Guinea . . . while it is true they are anxious for responsibility they do not want their tutelage period to be cut short . . . no critic of the colonial system has ever suggested to me an alternative in the case of so backward a country as New Guinea."

In *The High Valley*, Kenneth Read, as Margaret Mead has done in her many books, has given us a rare insight into the lives and minds of a primitive people. "Only the [social] anthropologist," says Read, "wants nothing from the people with whom he lives—nothing, that is, but information, nothing but an understanding of and an appreciation for the texture of their lives." In my own experience in New Guinea, no one thing is so difficult as the bridging of the gap between the "civilized" mind and the thought processes and interpretations of apparently simple events by people who are living the lives our own ancestors lived some thousands of years ago. This is the quality that makes the personal record by a trained anthropologist such exciting reading. He interprets the particular and thus allows us to understand the general. Read spent two years in intimate studies of the Gahuku tribes i the Trust Territory of New Guinea— high land of interior valleys totally un known to the world until the 1930's.

As Read has permitted us to see int the minds of these people. so Margare Spencer, with her facile and sympatheti pen and her wonderful eye for detai gives us the very atmosphere of livin and working among these people. *Doc tor's Wife in New Guinea*, and the mor recent *Doctor's Wife in Papua*, are de lightful books for those who would kno the areas as they exist today. And ther is sufficient detail about the past an the possible future to put her observa tions in perspective. She proves tha woman's place is not always in th home; a life shared with a husband i the field—be he doctor, naturalist, or mis sionary—can often give a woman som of the most rewarding years of her life

Hobart M. Van Deusen is the Assistan Curator, Archbold Collections, at Th American Museum of Natural History

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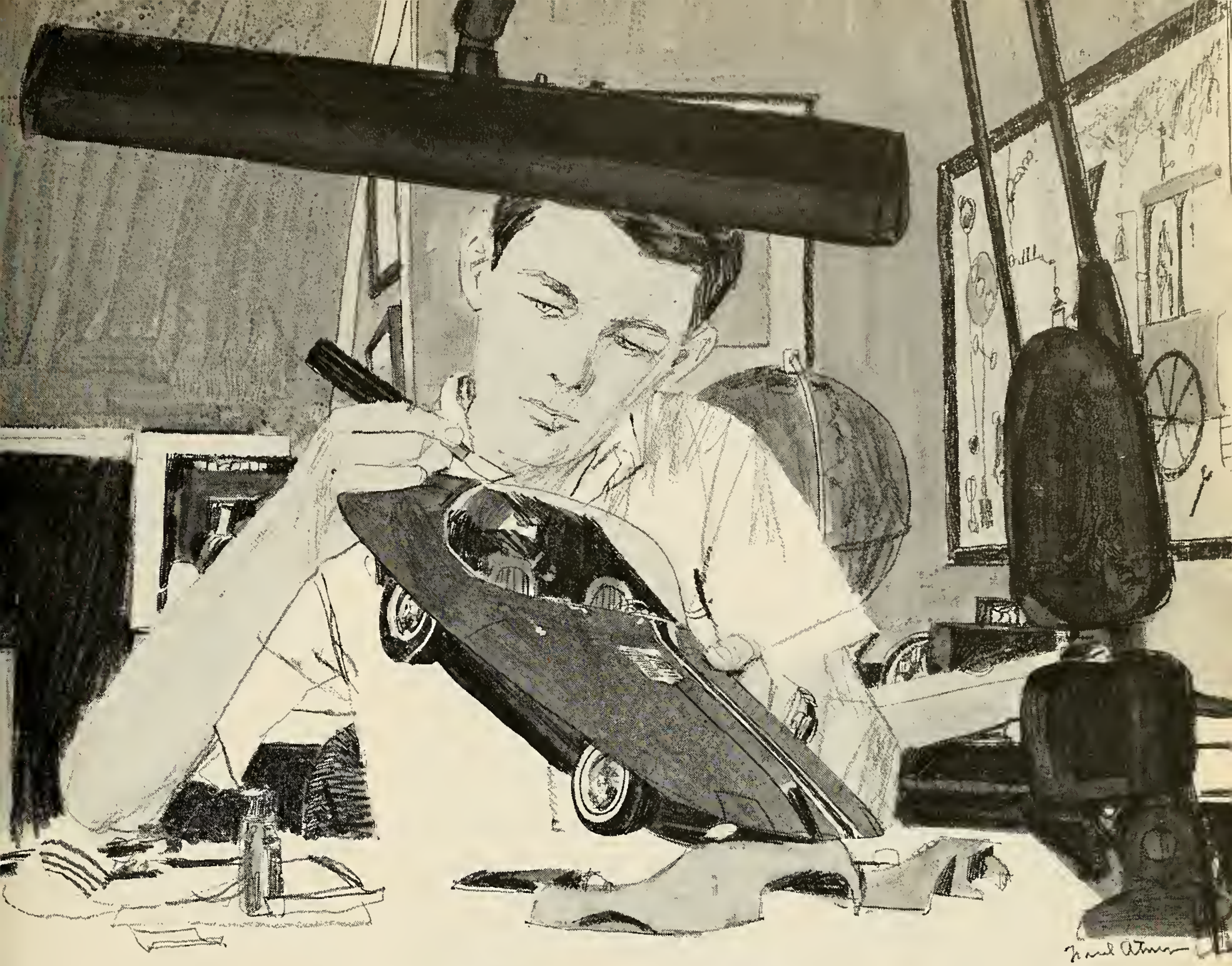
KEPLER'S DREAM, Translated by Patrici Frueh Kirkwood; Introduction by Joh Lear. *University of California Press $5.00; 182 pp.*

MR. LEAR's introduction and interpre tation, fully one-half of this book begins in the same manner as Brahms *First Symphony*—all at once. The reason for this seems to be that it is more an interpretation of Kepler's allegory than an introduction. Indeed, even the introductory aspect of the author's contribution assumes the reader has the background of a student of Kepler's life and times. His life was hard and full o frustrations; his livelihood often depended on the whim of a patron deeply involved in intrigues of court and state. These were times of political and religious unrest in a middle Europe that had a largely superstitious populace.

Kepler wrote this tale before 1600. but later modified and expanded it several times. It was intended only for private circulation, but at least one copy fell into the hands of less intellectual readers. Superficially, it is an account of a dream Kepler said he had in which he found a book written by a supernatural person who was transported to the moon, and describes how he made the trip and what he learned about the inhabitants of the moon and their life. The superstitious read into this allegory ideas other than those Kepler had intended, and branded his mother a witch. These outcomes were not really surprising, for allegories are supposed to be obscure, and Kepler's mother was admittedly odd and meddlesome. Several years of Kepler's life were spent in defending the old woman (successfully, at



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last) and in explaining his *Dream*. The posthumous publication of this work contains his footnotes, which are longer than the work itself.

In a way, almost no introduction would suffice to elucidate the setting in which Kepler conceived his *Dream*, for one would have to reproduce Kepler, himself, complete with his viewpoint of the world. Serious students of this era will be familiar with the historical background, and they cannot possibly ignore Mr. Lear's remarks. Taken with the rest of Kepler's works, the *Dream* helps fill many gaps in our understanding of Kepler's concepts of his world. Mr. Lear points out that in many of these Kepler seems on the threshold of anticipating a few of Newton's accomplishments. On the other hand, it is also possible to see a few ideas that seem surprisingly naïve. Is this just the 50 per cent success of a random thinker? No, the odds are decidedly in favor of Kepler, and one can surmise that had he had a more tranquil life, our debt to him would be much greater. In any event, our thanks are due to Mrs. Kirkwood and Mr. Lear for this revealing and scholarly contribution to our understanding of Kepler.

K. L. Franklin
American Museum—Hayden Planetarium

The Totem Pole Indians, by Joseph H. Wherry. *Wilfred Funk, Inc., $6.50; 152 pp., illus.*

The totem pole of the Pacific Northwest is one of the best-known of American Indian artifacts, challenged only by the familiar Plains Indian feathered headdress. Like the headdress, it has spread far from its area of origin, and now crude imitations can be found all over the United States, often standing in front of "trading posts" and other businesses, or simply serving as front yard decorations. Phone calls from frantic fathers whose sons have decided to earn a Boy Scout merit badge by carving a totem pole are routine at The American Museum. The Museum receives questions about totem poles from diverse sources: an advertising agency (what do they mean?), a banker (where can I buy one?), and a newspaper reporter (someone says he discovered one in Pennsylvania; is it possible?). Totem poles are clearly of considerable interest to the modern American.

The Totem Pole Indians, by Joseph H. Wherry, is a book that answers most of these questions about totem poles and furnishes a good deal of information about the Indians who carved them. The poles were made by a few tribes of Indians who lived on the Northwest Coast, a narrow strip of land along the Pacific from Puget Sound, Washington, to southern Alaska. After a few chapters providing a general description of the culture and history of these Indians, Wherry de-scribes the principal figures carved on totem poles and teaches the reader how to recognize them. Next comes a chapter on interpretation that will be helpful to all who have heard that totem poles can be "read." (They can, but only if considerable information is available about the mythology and history of the clan owning the pole.)

The erection of a totem pole in front of an Indian house was the occasion for an elaborate ceremony that featured, among other things, the distribution of valuable gifts to guests and, sometimes, the destruction of considerable property. Such ceremonies are now popularly known as potlatches and, next to totem poles, they are the feature of Northwest Coast Indian life that has most captured the public imagination. Wherry's discussion of the potlatch makes the sometimes neglected point that the ceremony was more than just ostentatious gift giving; it served important social, religious, and economic functions.

Totem poles can be seen today in museums of Canada, Europe, and the United States; and many old poles are still standing in Indian villages (Natural History, October, 1964). The American Museum has an excellent collection, although the larger poles have been cut into two or three parts to fit into the exhibition hall. For those who want to see them in their original setting, Wherry outlines automobile trips to the more interesting places.

The illustrations are the outstanding feature of *The Totem Pole Indians*. Almost every page has a photograph or drawing with a full and informative caption. While the book is written for adults, many children will enjoy the pictures.

Stanley A. Freed
The American Museum

Reptiles and Amphibians, by Zdenek Vogel. *The Viking Press, $12.50; 228 pp., illus.*

Keeping amphibians and reptiles in home vivariums, long a pastime in Europe, is becoming increasingly popular in the United States. Exotic species that once were available, if at all, only from specialized mail-order dealers, now turn up in the local pet store. Enthusiasts for such pets, therefore, should welcome a book by a European dealing with these animals. (The author is Czechoslovakian; the book was first published in German.)

This book provides an abundance of information on the design and maintenance of vivariums and on the care and feeding of the animals housed therein. Unfortunately, the author attempts to go far beyond this, and the book suffers from diffuseness of purpose and trivial coverage. A vast number of species seem-

ingly are mentioned for no other purpose than to comment on some minor aspect of coloration or behavior, and the comments are not always accurate. Readers accustomed to thinking of vivariums in terms of units for the home will be startled by statements such as, "The bite [of the king cobra] will even kill an elephant in quite a short time. As a rule it can be kept quite easily in a large vivarium." But this merely exemplifies the author's intention of serving the professional animal keeper as well as the amateur.

Illustrations form a prominent part of the book. The thirty-two color plates are of a quality far below those of other popular books published in recent years, but the numerous halftones are better than the color plates, and show a number of species not commonly illustrated in the popular or scientific literature.

The book is indexed by species and not by subjects, and one must look under both scientific and common names to cover a given species. The inadequate bibliography includes only ten titles.

RICHARD G. ZWEIFEL
The American Museum

THE GREAT SAHARA, by James Wellard. *E. P. Dutton & Co., $6.95; 350 pp., illus.*

THIS book is a well-intentioned effort to present the history of the Sahara to the general public. Unfortunately, it fails. James Wellard warns at the outset that he is not adding "to that vast literature of romantic rubbish . . . which purports to give a picture of what this part of the world is like." Yet, only one page later the reader learns that the "real desert" affords "a glimpse into the mystery of life in its most primeval form." Some of these glimpses are as follows: "lost rivers and streams" once linked the Niger with the Nile, "and they are still flowing in one form or another underground"; the "Arabs were to Africa what the Saxons were to Britain . . . innate barbarians hostile to civilized society: both wanted instinctively to smash it to pieces"; the Tuareg were "the only link" between "the Negro and the White world"; the Tuareg, however, "were basically thugs and bandits."

Wellard is understandably impressed, but not at all daunted, by the immense complexity and variety of data, much of it still unanalyzed by scholars, that pertain to the history of the Sahara. The opening half of the book takes the reader up to the age of European exploration. In these first 131 pages, the focus is primarily on the military accomplishments of the Romans. One of the author's conclusions is that "the metamorphosis of Africa from a land of 'feathered Libyans' and 'cave-dwellers who squeaked like bats . . .' into a land of splendid cities, villages, and farms was largely the

achievement of the Third Augustan Legion."

In the closing half of the book, Wellard offers a series of well-chosen selections from the diaries and accounts of early European travelers in the desert, and carries the reader on through the French conquest and occupation of the greater part of the Sahara. Wellard rightly contrasts the achievements of the *méharistes* (local troops officered by the French) with the less-than-glorious activities of the French Foreign Legion. Perhaps the best chapter in the book is a simplified but perceptive account of the White Fathers, a Catholic order, as soldiers and missionaries.

In a curious epilogue, Wellard reverts to offering more glimpses—not just of the Sahara, but of all Africa. On only one page, the reader is told that Africans north of the Equator are Moslem and those south of it are pagan, and that "the distinctive feature" of *négritude* (a highly complex political and literary movement originating in what was formerly French West Africa) is "the glorification of colour." This is journalistic simplification at its worst.

Several pages of notes list the sources that Wellard has consulted for each of his chapters. An end paper map simplifies the geography and trade routes of the Sahara. Two small sketch maps in the text show the possible journeys of a Roman general, and the route followed by Major Alexander Gordon Laing from Tripoli to Timbuktu. There are a number of mediocre photographs, and several of poor quality.

FRANCIS P. CONANT
Hunter College

FRAMEWORKS FOR DATING FOSSIL MAN, by Kenneth Oakley. *Aldine Publishing Co., $8.75; 355 pp., illus.*

DR. OAKLEY's book *Frameworks for Dating Fossil Man* was not intended for readers with only a casual interest in early man. This volume is of special interest to the advanced student or professional who needs a reference work to the complex literature relating to the dating of human fossil finds.

Dr. Oakley has already published a historical review of the attempts made in the past to date the earliest remains of man. This review, published in 1964 as a British Museum Bulletin, had been originally intended—along with the present work—to be part of a much wider study of the chronological placement of fossil men. Unfortunately, Dr. Oakley was forced to interrupt his work in 1961 because of ill health. In 1963 he was persuaded to bring the manuscript up to date and publish it in its present form.

In the Introduction, Dr. Oakley pro-

des the reader with a lucid summary of ıe various methods of relative and ab- ›lute dating that serves as a back- round for the text itself. The book has een divided into three parts. The first, ıtitled "Stratigraphical Dating," pre- ›nts the methods used to classify and ›rrelate the Quaternary deposits con- ıining human fossil finds and some of ıe most important stratigraphical se- uences. This includes brief chapters ıat deal with glacial chronology, ıanges of coast and sea levels, river ›rraces. the use of pollen and faunal vidence, and the use of sea cores to ıfer climatic fluctuations. The chapters n the stratigraphic sequences of the frican Pleistocene are of particular in- ›rest, because much of the work done ı the recent past is clearly summarized.

The second part, "Archaeological Dat- ıg," presents the major sequences of one tool traditions in the Old World s another type of evidence used to date ›ssil man. This section constitutes a use- ıl revision of a large part of Dr. Oak- ›y's classic text *Man the Toolmaker.*

The remainder of the book is a cata- ›gue of 300 human fossil finds, indicat- ıg the part of the stratigraphic and rcheological sequences to which each f the fossils refers, and its absolute date hen known. This catalogue will remain ıe most up-to-date available until the *ew Catalogue of Fossil Hominids,* ed- ed by Dr. Oakley and B. G. Campbell, ecomes obtainable.

The interpretation of the geological, aleontological. and archeological evi- ence necessary for the dating of fossil ıan is usually beyond the ability of ny one individual. We are therefore ıost fortunate that Dr. Oakley's vast xperience and profound grasp of this ›mplex field has provided us with such useful reference work. His text pro- ides more than 450 bibliographical ref- ›rences, an index of 1.500 names, and ıore than 300 notes. which are invalu- ble guides to the most recent publica- ons in this vast field.

The author stated in his preface that › had originally intended to produce a ork four times as long. Had it been ossible for Dr. Oakley to carry out his rst plan. he would surely have included ıapters on soil and sediment studies, ıd on fluorine, uranium, and nitrogen ating of bones. to which he himself has ade numerous contributions. Chapters ı radiocarbon and potassium-argon ating would also have been of interest.

Our understanding of the biological ıd cultural evolution of the hominids ›quires that both the sequence of the ›ssil man remains and the interval of me separating them be known. *Frame- orks for Dating Fossil Man* is a help- ıl guide to efforts made in this field.

Jacques Bordaz
New York University

Washington newsletter

By Paul Mason Tilden

DURING September of 1964, the 88th Congress passed three closely related acts that were of great interest to the conservation movement, perhaps most particularly to its preservation and protection segment. The three acts, Public Laws 88-606, 607, and 608, made recommendations relative to the future of vast federal landholdings commonly called the public lands and to the federal bureau that has jurisdiction over them—the Bureau of Land Management in the Department of the Interior.

Essentially, the public lands consist of that portion of the nation that has never been set aside for special federal purposes, such as parklands, wildlife refuges, recreational areas, game ranges, or other specifically designated uses, and land that has never been claimed by the public for homesteading or for mineral values. In total, these lands are still vast, constituting some 465 million acres scattered in a random pattern throughout the western states and Alaska. Individual tracts range from tremendous blocks of land to tiny plots that appear as mere specks of color on a public land map.

Over the years, many laws have been passed concerning the utilization and disposition of these public lands. Some of the laws are contradictory, at least in part ("not fully correlated with each other," to use a Congressional term), and some are archaic. The three new laws were passed to bring some order to a chaotic administrative situation. The first established a Public Land Law Review Commission to study existing land laws and procedures relating to their administration. The other two authorized and directed the Secretary of the Interior to classify public lands either for disposal or retention in public ownership, pending a report by the commission and possible further Congressional action.

For many years the Bureau of Land Management, as mere caretaker for the public lands, has been viewed by some Americans as a self-liquidating agency. Its business was to dispose of its wares until, in theory at least, there were no longer any public lands left. Indeed, there is an old saying among western cattlemen and miners, still heard on occasion, that "the main business of the Bureau of Land Management is to go out of business." Conservationists feel that, on the whole, the Bureau has done a fine job of land management without any really specific directives for the jo[b] and they wonder whether the Burea[u] might not eventually become a perma[-]nent agency with a fixed set of guidin[g] principles. They feel that the cattleman'[s] philosophy might itself be archaic. An[d] the trio of 1964 public laws seems t[o] say, indirectly, that this current o[f] thought has also occupied some Con[-]gressional minds.

Among the qualifications that Con[-]gress listed as important in the disposa[l] or retention of public lands were thei[r] potential for outdoor recreation (i[n] which the Bureau has recently made [a] modest start), for watershed protection[,] wilderness preservation, and, impor[-]tantly, "preservation of public value[s] that would be lost if the land passe[d] from Federal ownership."

Within the public lands there ar[e] thousands and thousands of fine natura[l] areas, large and small, that many con[-]servationists and scientists feel are wor[-]thy of protection for their recreationa[l] values, their scenic beauty, or their sci[-]entific interests: a fine cave and its im[-]mediate surroundings; an undisturbe[d] association of plants and animals; a[n] unusual geologic phenomenon; a spec[-]tacular canyon. There are many such special "spots" that, although perhaps not qualifying for protection under na[-]tional or state auspices, might be guarded under one or more of the cri[-]teria outlined in Public Law 88-607.

The Washington office of the Bureau of Land Management has been sympathetic to the notion that many such tracts might be managed for special purposes, and that a system of open space reserves might be developed. But there have been several difficulties. Obviously, it is not feasible for the Bureau's top-echelon personnel to canvass millions of acres of public lands. Rather, the headquarters staff must rely on recommendations from its state offices as to the number and size of potential open space reserves. And in some instances local planning has seemed to conservationists to be parsimonious in recommending sites—to reflect, in short, the cattleman's view of the Bureau of Land Management's destiny.

MR. TILDEN, a writer and editor in the nation's capital, often contributes columns pertaining to government activities and the natural sciences.

Many conservationists see the Bureau as administrator of a valuable system of outdoor recreational and natural lands that could complement the present holdings of national park, forest, and wildlife refuge systems. The Bureau has already accomplished some large thinking in this direction, but its good work can all too easily be modified by small thinking at local levels.

The Rampart Project

A little more than four years ago, the Secretaries of Interior and Army signed an agreement by which the Interior's numerous agencies would conduct field studies on the possibility of constructing a gigantic dam on the Yukon River in Alaska. The dam would back water up the river for 280 miles and would create a lake of some 11,000 square miles—as large as New Jersey and Rhode Island. This was the Rampart project, which would provide a hydropower installation with a potential annual energy production of more than 34 billion kilowatt-hours. It would also lead to the destruction of natural surroundings to an extent unparalleled in the history of American dam building.

Conservationists had been aware of the scheme for some years prior to the initiation of the field studies, but had generally given it little attention on the grounds that it was fantastic. They could not imagine how the 250,000 inhabitants of Alaska (including its military personnel) could absorb electrical energy in such quantities. (The 1964 use in the state was 627 million kilowatt-hours.) Also, high-wire transmission facilities to the nearest large industrial centers of the Pacific Northwest, where a surplus of electrical energy already exists, were estimated at somewhere between 550 million and over a billion dollars. The scheme sounded like a pleasant engineering exercise, and hardly a cause for serious concern. Fantastic or not, however, the matter has become an active conservation issue in the past year, and it is likely that legislation to launch the project will be introduced in the second session of the 89th Congress.

Conservationists are, quite properly, deeply concerned with the human aspect of the projected inundation. The dam would lie across Rampart Canyon, near the tiny village of Rampart, about 100 miles northwest of Fairbanks, and would dispossess some 2,000 Athabascan Indians of their ancestral hunting, trapping, and fishing lands in the lake-studded Yukon Flats to the east. Proponents of the project have argued that the Indians would be given good jobs in construction and maintenance, but the skilled nature of all but the most menial dam-connected work seems to rule out the argument.

The most incredible destruction, however, would be wrought on the wildlife and wildlife habitat of east-central Alaska—on the moose, grizzly bear, caribou, and small-animal ranges of the Yukon River Valley, the valleys of major tributaries like the Porcupine, and on the salmon fisheries so important in the economy of the Athabascan Indian. It would also destroy the breeding ground of millions of migratory and other waterfowl that have always used the 36,000 lakes and ponds of the Flats.

Of the nine Interior Department agencies involved in field studies of the Rampart project, all but one bureau responded dutifully to the Secretary's evaluation call with an "amen." The black sheep of the Interior family was the Fish and Wildlife Service, which concluded, in its *Report on Fish and Wildlife Resources Affected by Rampart Canyon Dam and Reservoir Project*, that "construction and operation of the Rampart Canyon project would result in enormous losses of fish and wildlife resources. . . . Even with mitigation measures now deemed most feasible, losses of fish and wildlife would be so great that this Service must oppose authorization of the project."

Rampart proponents have bitterly denounced the Service's position as "unprogressive," and have brought into question on the floor of Congress the Service's quality of leadership. But the conservationist point of view has also had Congressional defenders. One of these, discussing the project in the House of Representatives recently, humorously told House members that "the Rampart project was announced in mid-September 1963, under what could have been the spell of the aurora borealis, which is seen most frequently at the time of the equinox and is supposedly of electrical origin." The Congressman ended his discourse with a statement with which most conservationists could easily agree: that "the likes of Rampart has no place there or anywhere else . . . for it would be too expensive even if it had the capacity to generate a competing display of northern lights."

The Fish and Wildlife Service has not, up to the present time, backed away from its courageous position. Nor, so far as this column can learn, has it any intention of doing so.

On Endangered Species

In a previous installment of this "Newsletter" (Natural History, August-September, 1965) I mentioned, in a discussion of the Kaibab squirrel and its prospects as a viable native species, the dim outlook for a number of other native animals. These include certain mammals, fishes, birds, and a reptile that are currently listed by the Fish and Wildlife Service as in immediate danger. I received a number of inquiries about the availability of the Service's tabulation

of endangered species, including several letters from biology teachers who saw in the tabulation a valuable science and conservation aid.

The "Newsletter" discussion of the subject was based partly on the preliminary draft of the first revision of the Fish and Wildlife Service's *Rare and Endangered Fish and Wildlife of the United States*. This 213-page, large format, loose-leaf publication was printed in limited quantity by the Service, primarily for its own use and that of non-Service wildlife specialists. The valuable work has not been widely available, although I have discussed with the Service the possibility that it be republished—at least in a condensed version. However, fully realizing that requests of this nature can pose severe budgetary (and sometimes policy) questions for government agencies, I can only report that the suggestion was received with both courtesy and interest.

Concerning the Parks

During the latter part of last summer the Congress authorized the establishment of the Assateague Island National Seashore off the coasts of Maryland and Virginia. This ended a preservation battle that had been waged, more or less constantly, for thirty years.

Assateague Island is a 33-mile link in the long chain of barrier, or offshore, beaches that stretches, with some gaps, from Massachusetts to the Florida east coast. The island runs south from Ocean City, Maryland, across the head of Chincoteague Bay, to a point just off Wallops Island in the jurisdiction of Virginia. The portion of the island in Virginia, approximately one-third of the whole, has for many years been the Chincoteague National Wildlife Refuge, under the Fish and Wildlife Service.

The legislative history of the effort to preserve Assateague has been almost as stormy as the Atlantic waves that from time to time reshape the island's low-lying dunes and marshes. The National Park Service, in a 1935 survey of east coast national seashore possibilities, noted Assateague as one of twelve areas of outstanding potential. Bills were introduced to create such a preservation, but nothing came of them.

Another survey was made twenty years later, but by then the Maryland portion of the island had been acquired by a real-estate developer. The Park Service seemed ready to give up, saying that "the advanced stages of real-estate development appear to preclude the possibility of this area being set aside for public recreational use." The situation was not so bad as that, however, even though plots had been laid out, and fifty or so summer houses had been built. Power and telephone lines had been strung, and a black-topped road, built on the shifting sands, striped the island lengthwise to the border of the wildlife refuge. (Traces of this road can still be seen.) But for the most part, the island remained in its pleasant, primitive state.

As the years passed, the question of public status for Assateague remained undecided. After a destructive spring storm in 1962, only a handful of cottages remained, some of them damaged, and these were further battered during a severe storm in the winter of 1963. The real-estate business on Assateague looked less and less promising, and became particularly bleak after the state of Maryland blocked further development pending acceptable plans for sewage disposal. The island's fate became a lively topic again.

By mid-1965, however, sanitary standards acceptable to the state had been worked out by the developer, and there was an immediate threat of further subdivision and construction. The state had gone as far as it could in forestalling private development, and as the bulldozers literally were rolling toward Assateague, conservationists looked to Congress for swift legislation. Congress responded with an act creating the Assateague Island National Seashore—within which the Chincoteague Wildlife Refuge would retain its identity—and President Johnson immediately signed the act as Public Law 89-195.

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New York, N. Y. 10024

Two other preservation possibilities that the National Park Service has recently advanced also merit serious public attention. The first of these, on which the Service has already made a formal proposal, concerns a national lakeshore on the south shore of Lake Superior at the tip of the Bayfield Peninsula in Wisconsin. The area to be set aside would include two large mainland units plus twenty-one of the gemlike Apostle Islands off the northeast tip of the peninsula. It would be called the Apostle Islands National Lakeshore. The pristine islands would be managed as natural wild areas, while the two mainland areas—Red Cliff and Kakagon-Bad River Units—would provide camping and boating facilities, hiking and nature trails, and administrative headquarters. The proposal also contains a recommendation, by now apparently routine in such proposals, for a "scenic drive" along the lakefront, which would allow visitors who are unable or unwilling to leave their automobiles "to enjoy the shore line's special interest and beauty."

The second preservation undertaking that is currently under discussion—but which was not in official proposal form at the time of this writing—involves the enlargement of the Organ Pipe Cactus National Monument in southern Arizona and its reclassification as a major national park. To enlarge it, most of the huge Cabeza Prieta Game Range, which flanks Organ Pipe Cactus to the west and north, would be added, creating a park of nearly a million and a quarter acres. This would be a project of heroic proportions—one over which conservationists and scientists would be enthusiastic.

Organ Pipe Cactus National Monument was created in 1937 by Presidential proclamation. Its main purpose was to protect the finest of the few organ pipe and saguaro cactus stands of the Sonoran Desert, along with a profusion of other cactus species, some of them rare, and various animals such as the Elf Owl, the White-winged Dove, and the Gilded Flicker. The Cabeza Prieta Game Range, running west from the monument for sixty miles along the Arizona-Mexico boundary, is administered by the Fish and Wildlife Service and was originally established to protect desert bighorn sheep. It is a wild, broken, colorful expanse of range and basin land, shunned by humans during the summer months because of its intolerable aridity and heat, but mild, pleasant, and sometimes bright with desert flowers during winter and spring. Aside from its resident population of desert bighorns, the game range supports javelina, or wild pig, and a small population of antelope.

A National Park Service team of specialists recently concluded a field study of both the monument and game range, and has submitted a favorable report recommending the creation of a 1,930-square-mile Sonoran Desert National Park. I am told that the Park Service proposal should be made public before the end of 1965, and that legislation may be introduced early in the second session of the 89th Congress. A preliminary assessment of the park's future, legislatively speaking, seems to indicate considerable opposition from Arizona sportsmen's organizations, and, perhaps, from the Department of the Army, since the Cabeza Prieta Game Range is used by the Air Force from time to time for air-to-air missile practice.

[Since the above was written, Arizona's Congressman Udall has introduced a bill to establish a Sonoran Desert National Park, but the Park Service has not made public a formal park proposal—a rather unusual proceeding. The bill, H.R. 11695, was referred, as are all national park bills, to the House Committee on Interior and Insular Affairs.]

The World of The Phoenicians

By Cyrus H. Gordon

The Phoenicians are one of the most important peoples in history. The name derives from their word *puni*—"pertaining to purple dye," which the Phoenicians made from the shellfish murex (NATURAL HISTORY, January, 1964) and traded throughout the ancient world. *Phoeni,* as in Phoenician, is a variant of *puni,* as in Punic. The Phoenicians set the pattern that the Greeks followed in colonization and trade. We still use a form of the Phoenician alphabet. But there is no clear definition of precisely who the Phoenicians were.

It is agreed that the Phoenicians were a nautical Mediterranean people speaking a northwest Semitic language resembling Hebrew. They flourished mainly in the second and first millenniums B.C., and their homeland is generally thought to be the Syro-Palestinian coast from Tyre to Aradus, with Tyre, Sidon, and Byblos as the main centers. Starting with the ninth century B.C., when the Phoenicians founded Carthage (the traditional date is 814 B.C.), the western half of the Mediterranean became the scene of Punic (Carthaginian or west Phoenician) settlements. Such is the more or less generally accepted view, but as is so often the case, the consensus must be revised in keeping with the evidence. Modern discovery and research have vindicated the ancient Greek traditions, which held that Phoenicians of the Late Bronze Age (1600-1200 B.C.) were spread all over the islands and continental shores of the east Mediterranean—Egypt, Palestine, Lebanon, Syria, Asia Minor, Greece, the Aegean Islands, Crete, and Cyprus. In fact, about 1500 B.C., the most important branch of the Phoenicians were the Minoans based on Crete. The Greeks indicated the Phoenician origin of the Minoans in the legend of Minos. He was the son of the Tyrian princess Europa, whom Zeus carried to Crete from Phoenicia. Cadmus, Europa's brother, became king of Thebes in Boeotia and introduced Phoenician writing there. According to another Greek tradition, Danaos, a Phoenician from the Nile Delta, became king of Argos and introduced Phoenician writing to Greece. These and similar traditions correctly reflect the spread of the Phoenicians throughout the east Mediterranean shores, and their pre-eminence among the classical Greeks' forerunners.

Illustrations by Robert J. Lee

Ships of the Phoenicians plied the Mediterranean, Red, and Black seas; the Indian and Atlantic oceans. Among their trade items were carved ivories, as he at top, and panel that may have been used as inlay.

Reconstruction of now-obliterated Solomon's Temple is based on Old Testament description. Built in 10th century B.C., it is most famous Phoenician edifice. Ivory sphinx, right, is unlike Egyptian forerunners.

In the light of the above, we must give the Phoenicians a broader and more flexible definition than the commonly accepted one. In the Middle and Late Bronze Ages (2000-1200 B.C.) they were centered in Crete (especially from 1800 to 1400 B.C.), and controlled a maritime order that the Greeks called the Minoan thalassocracy. That Greek tradition is accurate is corroborated by the Phoenician nature of the Minoan language (NATURAL HISTORY, November, 1963). It was only when the Mycenaean Greeks strengthened their grip on what is now Greece that the Phoenicians were forced to center themselves in the region commonly referred to as Phoenicia (now on the coast of Lebanon and Syria).

The Phoenicians were characterized not only by their northwest Semitic speech and their abode along the Mediterranean shores but also by their way of life. They were a navigational and trading people, whose cities were ports suitable for the small craft of antiquity. Sometimes the bulk of the population lived on the coast, while the stronghold was an offshore island. This pattern is best preserved at Aradus, a Phoenician island off the coast of Syria; the larger community, however, resided (and still resides) at Tartus on the mainland. Tyre also once fit into this pattern, but Alexander the Great conquered that island stronghold after constructing a causeway that joined it to the mainland. Ever since, Tyre has been a small peninsula. Trading interests sometimes took Phoenicians inland to barter or to exploit mines, but at such times they set up trading stations rather than inland cities.

Phoenicians were probably in the Levant by 3000 B.C., but it is only at the beginning of the Middle Bronze Age that they are first attested to by personal

names at Byblos. By then the east Mediterranean had long been penetrated by at least two highly civilized and literate cultures: the Mesopotamian and the Egyptian. Most of the land and sea routes then in use had been operative since at least chalcolithic times, deep in the fourth millennium B.C.

During the third millennium B.C., Mesopotamian kings, including Sargon and Naramsin of Akkad, pressed their conquests to the shores of the Mediterranean. Assyro-Babylonian culture permeated the Levant to such a degree that the international correspondence found at Tell el-Amarna in Egypt is written in Babylonian. Much of what we know about Tyre, Sidon, Beirut, Byblos, and other Phoenician centers in the first half of the fourteenth century B.C. comes from these Amarna tablets. In the fourteenth and thirteenth centuries B.C. at Ugarit, on the coast of what is now Syria, the normal language of international diplomacy and royal land grants was Babylonian. Egyptian influence was also strong in Phoenicia. An Egyptian temple was in Byblos in the third millennium, and many of the texts and monuments found in Phoenicia are Egyptian. However, we must not, as a result of these influences, picture the ancient powers as empires with rigid, hostile borders. Instead, beyond the natural limits of their homelands they were interpenetrating commercial spheres of influence. Rather than trying to strangle Phoenician enterprise, they generally made use of it, so the continental empires and the seafaring Phoenicians normally complemented, rather than rivaled, each other. The fine array of Assyrian and Egyptian rock sculptures and inscriptions at Dog River, north of Beirut, vividly illustrates that Phoenicia was the crossroads of the ancient world. Obviously, Pharaohs and Mesopotamian kings reached Phoenicia and satisfied their urge to commemorate their arrival by having their texts carved side by side there.

Origins are elusive, because a people must originally have come to any given place from somewhere else. Phoenician origins are no exception. Herodotus (7:89) states that they came to their classical abode from the Red Sea. They kept Red Sea interests, as is clear from the Bible, which tells of Solomon's treaty with Hiram of Tyre to operate a Red Sea fleet in the tenth century B.C. (I Kings 9:26-28).

The earliest textual evidence of the Phoenicians that can now be read is from Minoan Crete, starting about 1800 B.C. Although the language is Phoenician, a number of Egyptian personal names point to the Nile Delta as the principal source of the Minoan palace builders. Their Egyptian origin is supported by the absence of hearths in the Minoan palaces, indicating that a warm climate existed in the builders' homeland. Egypt and Palestine are the only countries with outlets on both the Red and Mediterranean seas, and it seems likely that the early Phoenicians facilitated trade by operating on both bodies of water. In any case the Nile Delta, unlike Upper Egypt, was inhabited by Semites as well as Egyptians; among them the Phoenicians were prominent. Since the main thrust of the Minoans and later the core of the Hebrew nation (in the Exodus) both came from the Delta, the latter can fairly be called the cradle of both the first European civilization and biblical Israel.

The Minoan thalassocracy might have been a far-flung Mediterranean power with a government centralized in Knossos, but this is far from certain. We do, however, know that in later times the Phoenicians were not organized into any unified empire, but were city-states, each ruled from a coastal capital. Tyre and Byblos, for example, functioned simultaneously and independently. Each would hold on to and cultivate enough adjacent farmland to guarantee an adequate food supply. But the main occupation was maritime trade, and to foster it, each city-state established over-

seas posts and stations as well as colonies. Sometimes the colonies outstripped the mother city in importance and power. Such was the case with Carthage—a colony of Tyre—which commanded so many sea lanes and so much territory in the west Mediterranean that she threatened the power of Rome and was eliminated only after the long and bitter Punic Wars, which ended with the city's destruction in 146 B.C.

The Phoenicians founded colonies on the Black Sea, as well as in the Aegean as far north as Thasos, where they established a settlement, exploited mines, and built a temple (Herodotus 2:44; 6:47). Cyprus nurtured Phoenician settlements, which persisted side by side with Greek towns into Hellenistic times. Phoenician texts come from Athens and Piraeus. Asia Minor had its Phoenicians, and the city-state of Adana, in Cilicia, was writing its royal inscriptions bilingually in Phoenican and hieroglyphic Hittite around 720 B.C., as we know from the long Karatepe inscription in King Azitawadd's palace, discovered by chance in 1946. Farther west, Phoenician and Punic inscriptions attest to settlements on Malta, Sardinia, Sicily, Ibiza, Spain, France, and North Africa (Egypt, Libya, Tunisia, and Algeria). In 1964 a bilingual in Phoenician and Etruscan was found at Pyrgi on the west coast of Italy about thirty miles north of Rome. Thus today Phoenician is providing a key to the decipherment of problematic languages such as Etruscan and hieroglyphic Hittite.

The language known as Iberian in Spain was perhaps Phoenician or, more exactly, Punic, as Iberia would more likely be under western (Punic) than eastern (Phoenician) influence. Cicero, in *De Divinatione* 2:64, speaks of "Carthaginians or Spaniards" who "might be talking in the Roman Senate without an interpreter." Cicero does not have Latin in mind. Since Carthage exploited and colonized Spain, he might possibly have meant that the two groups of foreigners spoke Punic, for he mentions them together. Although other explanations are conceivable, this one is supported by the presence of Punic words such as *qrt*, "city" in the Iberian texts; *qrt* was pronounced *cart*, as in Carthage, which means "new city."

It is known that the Phoenicians circumnavigated Africa under the sponsorship of Pharaoh Necho in the seventh century B.C. (Herodotus 4:42). The expedition sailed down the east coast, rounded the Cape of Good Hope and returned through the Strait of Gibraltar. As they rounded the Cape, the crew noticed that the sun was on their right—a fact that Herodotus chronicled but did not believe. However, it is precisely this detail that confirms the Phoenician report, for without realizing it they were in the Southern Hemisphere, and as they sailed west past the Cape, the sun would indeed have been on their right. Ancient writings tell of two Carthaginian expeditions in the Atlantic about 425 B.C.: Himilco's to the north and Hanno's to the south of Gibraltar. There is no doubt that these intrepid sailors explored the waters of the Atlantic in quest of trade and raw materials. The *Periplus* of Hanno tells us that his expedition founded colonies on the west coast of Africa. Bold scholars now and then claim evidence for Phoenicians in the Americas long before Columbus. Such speculations are generally considered to belong to the "lunatic fringe" of scholarship, but it would be a mistake to scoff at them as preposterous. The Phoenicians were daring, and while many crews may have perished, a few may have reached the Americas. Some of today's "lunatics" may emerge as tomorrow's prophets.

The clearest evidence for the presence of Phoenicians is epigraphic, for their texts are our surest guide. The Phoenician language is a group of closely related dialects belonging to the Canaanite branch of northwest Semitic; it is so close to Hebrew that it is hard to say whether some borderline texts should be called Phoenician or Hebrew. No speech barrier prevented the Hebrews and Phoenicians from understanding each other; the spoken dialects of northern Israel and southern Phoenicia were indistinguishable at the countries' borders.

Most of the existing Phoenician and Punic texts, in the familiar form of the Phoenician ABC, are dedicatory or funerary. Some are royal inscriptions with historic data. But there is virtually no literary content in such texts, even though we know from biblical and classical sources that Phoenician civilization was highly developed in literature and art. The situation changed as recently as 1929, when a new literature on clay tablets was first discovered in the ruins of Ugarit. This literature must be close to that which was current in the classical Phoenician cities. Some of the specific texts were known all through Canaan, as is clear from biblical references to their contents. Ezekiel (14:14-20; cf. 28:3) refers to a legendary Daniel and his progeny who, like Noah and Job, had survived catastrophe. The Daniel in question cannot be the familiar Daniel of the lions' den, who belongs to an age after Ezekiel. Ugarit has produced tablets inscribed with the legend of Daniel, whose son Aqhat died but was revived. We may be sure that a composition current at Ugarit, and familiar to a Hebrew author, was well known throughout Canaan, which included the Phoenician cities. Much of Ugaritic literature is mythological. Since most of the gods in the myths are the standard Canaanite/Phoenician deities (El, Asherat, Baal, Anat, Astarte, Reshef, Yamm, Mot), we may assume that the literature of the Phoenician cities included texts much like the mythical poetry at Ugarit.

In addition to the religious myths, Ugarit has yielded rituals, lists of offerings to the gods, and other tablets of a religious character. The religion of Ugarit was similar to that of classical Phoenicia; its chief concern was fertility. Baal (helped by the goddess Anat) must triumph over the forces of death and sterility. The myths tell of Baal's battle against those forces: how he suffered defeats (and even death) but eventually emerged triumphant. Such myths went hand in hand with rituals performed to secure fertility and general well-being for the realm.

The religion functioned at two levels, cosmic and

local. The gods are usually the cosmic nature gods of fertility, sterility, earth, sea, sun, moon, stars, and so forth. Each locality, however, had its own local manifestations of one or more great gods. For instance, Asherat is the wife of El, the head of the pantheon, and was a cosmic deity corresponding to Hera, wife of Zeus. But she was also worshiped as the local, or patron, goddess of Tyre and Sidon, and as such is referred to in the Ugaritic epic of King Kret. The religion of the Phoenicians and Carthaginians had both its aesthetic and barbarous sides. The myths, rituals, and pageantry have an aesthetic appeal, but to anyone raised in the Judeo-Christian tradition, the orgiastic rites and the human sacrifices are repugnant.

Phoenician art was justly famous. Their carved ivories were prized for their beauty and were used to decorate palaces and private mansions in Mesopotamia, Greece, Israel, and other lands beyond the confines of the Phoenician cities. The ivory houses mentioned in Amos 3:15 refer to mansions with furnishings inlaid with Phoenician ivories. Since Phoenician art borrowed so much from Assyria, Egypt, the Aegean, and elsewhere, it was susceptible to great variation, which depended on harmonious combinations of various elements and on the creative abilities of the artists. The status their art forms achieved can be seen in King Solomon's decision, in the tenth century B.C., to use Phoenician craftsmen and materials for building his Temple, which was the most famous, and possibly the finest, product of Phoenician architecture. Its construction and adornment are described

Greek-influenced "Sarcophagus of Alexander," below, of 4th-century B.C. Phoenicia, is Pentelic marble. Ivory with lotus blossoms is Egyptian in style.

Ivories from Nimrud show influences from other cultures borrowed by wide-ranging Phoenicians, who still developed their own distinctive style.

in 1 Kings, chapters 5, 6, and 7 (cf. Ezekiel 40 ff.). The Temple site is now covered by the precincts of the Dome of the Rock in Jerusalem.

The ruling class of the Phoenician cities was comprised of their merchant princes. The values of such a society were naturally materialistic, and acquiring the property of others by hook or crook seemed so natural that there are descriptions of their most beloved gods using their power to wrest property from those who refused to sell or part with it gracefully. Even Baal is described in the Ugaritic myths as covetous; indeed, the texts use the same word as in the Tenth Commandment, which forbids coveting. There can be little doubt that the Tenth Commandment was evoked in opposition to the Canaanite standards exemplified in Phoenician religion and life. It was the goddess Anat who had the hero Aqhat, son of Daniel, murdered so that she could take possession of the wondrous bow he had refused to sell her. The clash between Phoenician and Hebraic values is also illustrated in the account of Naboth's vineyard (1 Kings 21:1-28), which tells of the Hebrew King Ahab, who wanted Naboth's land. Naboth refused to sell, so all Ahab could do was sulk —Hebrew values forbade the king to wrest property from an unwilling subject—but his Phoenician wife, Jezebel, had a different approach. She could not understand her Hebrew husband's scruples, and true to her native values, she approached matters in much the same way as her goddess Anat did in the sacred Canaanite texts. Just as Anat had arranged the death of Aqhat in order to confiscate his property, so Jezebel arranged for false witnesses to testify against Naboth. He was put to death and his property was forfeited to the crown. The modern reader of the Bible is apt to consider Ahab a good, although weak, man and Jezebel a thoroughly bad woman. But this oversimplified appraisal misses the point. Jezebel was as normal a Phoenician as Ahab was a Hebrew. She was following the example of her gods, even as Ahab was trying to follow the precepts of his God. The tragedy of their marriage was the basic conflict in their native ideals. Jezebel's standards were precisely those that the Hebrew lawgivers and prophets consciously opposed. In fact, we cannot begin to understand the Old Testament until we grasp the nature of Phoenician values.

The significance of the Phoenicians can be judged by their effects on subsequent history. Their pattern of plying sea trade and establishing colonies on distant shores of the Mediterranean world provided the precedent for Greek sea trade and colonization. In connection with their trading activities, they transmitted and developed business institutions that in some cases

can still be felt in our contemporary world. For example, to buy services or merchandise by giving a pledge as security pending final payment has a special terminology in Phoenician. The pledge is called *ʿarrabon,* which came into Greek as *arrabon,* into Latin as *arrabo* (genitive *arrabonis*), and into French as *les arrhes.* The presence of the Phoenician word in Europe as far west as France bears witness to the Phoenician impact on Western economy. Still more interesting (because it is more fundamental) is the southern Phoenician/Hebrew term of *rosh* for "capital" (principal that produces interest). In early times, barter was the normal form of business dealing. The first people on record to lay the foundations of capitalism were the Mesopotamians in the third millennium B.C., who provided for the investment of principal to earn interest. The Sumerians called capital *sag,* "head"; the Babylonian word *qaqqadu* had the identical meaning. The spread of Mesopotamian trade brought the institution and its terminology to the Mediterranean shores where it was picked up by the west Semites who called capital *rosh* or *resh* (depending on the dialect), which also means "head." The Greeks called capital *kefalaion* (from *kefale,* "head"); the Romans called it *caput,* "head." It is from the last that our words capital and capitalism are derived. Thus the terminology helps to establish the role of the Phoenician traders in spreading the basic features of capitalist economy to our Western world.

The most important single contribution of the Phoenicians was the development and spread of the alphabet. The tablets found thirty-seven years ago at Ugarit were written in cuneiform script quite unlike the usual Phoenician alphabet in appearance. However, it actually is the same alphabet—not only in principle but in the order in which the letters were learned. Whole blocks of letters (such as *h i/j k l m n o p q r s t u*), which have come down to us from the Phoenicians via the Greeks and Romans, were already in that fixed order in the elementary school tablets written at Ugarit in the fourteenth century B.C.—before the birth of Moses, and much before the traditional date of the Trojan War. The principle of the alphabet is, in its purest form, simple: each phoneme (distinctive sound) in the language is represented by only one symbol. Since most languages have between twenty and thirty-five phonemes, they can be written alphabetically with a limited number of symbols. Ugarit had an alphabet of thirty letters; the Phoenicians and Hebrews got along on twenty-two by not having letters

Punic burial urns from Carthage often contained ashes of cremated infants, left. Sphinx, far left, is typical of many ivory Phoenician art objects.

for the vowels; English has twenty-six. The alphabetic principle so simplified the problem of literacy that it gradually displaced the more cumbersome syllabic and ideographic systems of Mesopotamia and Egypt. The impulse toward simplification was favored by the need for popular education to help carry on Phoenician trade. Egypt and Mesopotamia had large scribal schools and centers connected with temples and palaces, but the Phoenician operational unit, the sailing vessel, was so small and the "fleet" was so big that a large number of scribes was needed. Actually, the man who kept the log and the business records on a small vessel might have been a sailor with scribal responsibilities added to his primary role of boatman. This meant that the Phoenicians, to train an adequate number of scribes quickly, had to develop a simple writing system that could be taught easily.

There has been considerable controversy as to where the Phoenicians transmitted the alphabet to the Greeks. This question can now be answered. It was on Crete, as stated by the Hellenistic Cretan writer Dosiadas. In Cretan communities like Dreros, where Phoenicians and Greeks lived side by side and bilingual texts were written, the same alphabet is used for writing both the Phoenician and Greek versions. The alphabetic principle has been found in such Asiatic communities as Ugarit of the Late Bronze Age, but it lacked the five-vowel system of *a e i o u*. On Crete in the Middle Bronze Age—about 1800 B.C.—the Minoans were already using a syllabary in which each symbol stood for a consonant followed by a vowel. The vowels were five in number: *a e i o u*. Thus there were five *p*-signs: *pa, pe, pi, po, pu*; five *t*-signs: *ta, te, ti, to, tu*; etc. When the alphabet was introduced by other Phoenicians during and after the Late Bronze Age, the Cretan population (both the Semitic "Eteocretan" descendants of the Minoans and the Mycenaean Greeks), long accustomed to indicating *a e i o u*, felt the need for graphically indicating those—and only those—five vowels. There is little doubt that the Phoenicians developed what we now call the Greek alphabet, including the five vowels, in its early Cretan form. (Only later did the Greeks add four new letters after *u* and use *eta* vocalically.) The Greeks themselves called their script the "Phoenician letters," and Dosiadas knew that the Phoenicians on Crete transmitted the alphabet to the Greeks because the process was still going on in his native island during his lifetime. We have among the Phoenician Eteocretan inscriptions—in addition to the earlier ones going back as far as the sixth century B.C.—at least one written as late as 300 B.C.; others must have been written still later.

One of the most significant developments in archeology is the vindication of the ancient Greek tradition that the pioneers of their civilization were primarily Phoenicians. This applies to all the coasts of Asia Minor, Cyprus, Crete, the Aegean, and the Greek peninsula, as well as of northeast Africa and Phoenicia proper. The Phoenician character of the people we call Minoans explains, among other things, how Greek and Hebrew civilizations are parallel structures built on essentially the same foundation, for both of these classical peoples built on the heritages of their Canaanite/Phoenician predecessors. A somewhat similar development was to take place in the Roman west Mediterranean. North Africa, Malta, Sicily, Sardinia, southern France, the Balearic Islands, Ibiza, and Spain had many Punic settlements. Eventually Rome triumphed over those Semitic communities, but in doing so was influenced by them. Plautus' Latin play called *Poenulus* (produced in 194 or 193 B.C.) has some Punic dialogue recorded in Latin letters, so Roman audiences must have included people who understood enough Punic to enjoy the play in its entirety. The influence of Punic on Latin is witnessed by the fact that *have* or *ave* ("hail!" or "be well!") is the Punic imperative *have* ("live!").

Our Phoenician heritage is with us in our daily lives, not only when we hear "Ave Maria" sung, or are involved in some capitalistic enterprise, but, indeed, each and every time we use a single letter of our ABC.

Phoenician tribute bearers, below, are on Persepolis relief. Empire of Medes and Persians utilized these people for their naval value. Leptis Magna, right, on Libyan coast, is most impressive of Punic sites.

Surinam Animal Rescue

NEW DAM TRAPS WILDLIFE IN HIGH WATER

by J. ROBERT SMITH

In the construction of a hydroelectric dam in Surinam, thousands of animals were displaced by the flooding of an 870-square mile area, and the work of transporting them to a habitable place fell to the International Society for the Protection of Animals.

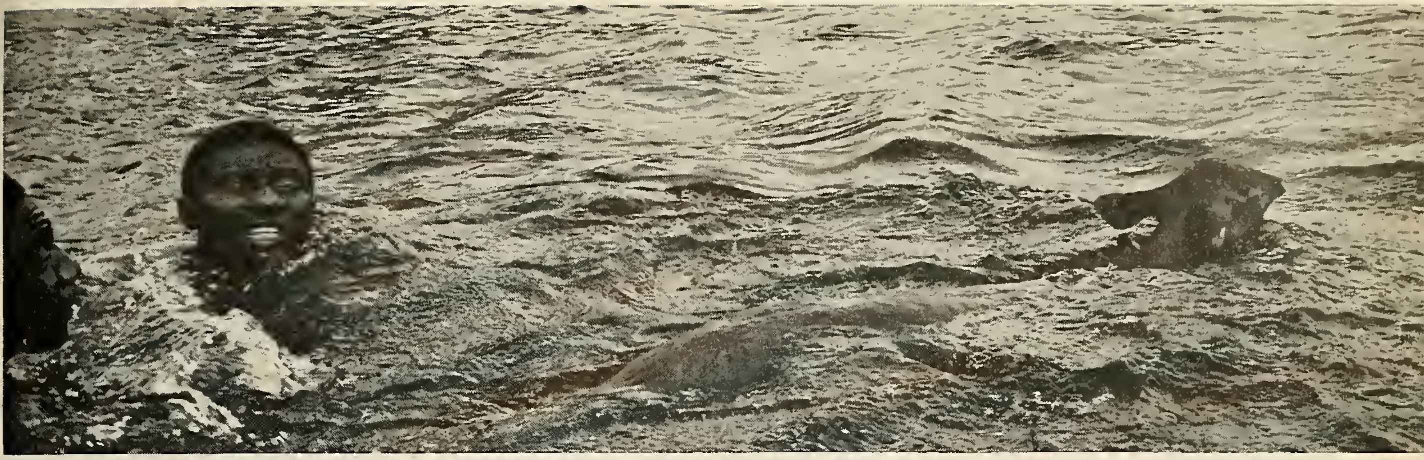
The I.S.P.A. was established in 1959 through the co-operation of Dr. Eric Hansen of the Massachusetts S.P.C.A. and the Royal S.P.C.A. in London. Its formation stems from one of the earliest problems that faced animal welfare societies—that of the transportation of livestock and other creatures by ship. Under the new regulations instigated by the I.S.P.A., animals are checked prior to sailing and inspected again upon arrival at their destination. In many cases, investigation proved that no safeguarding laws existed, or if they did, they were not enforced. Through the assistance of this new central organization, local societies were able to effect changes in the handling of animals in transportation and to obtain directives for the proper construction of shelters and clinics.

The catastrophe threatening the Surinam animals came to the attention of the Society in March, 1964, through a letter from the humane society in Paramaribo, which was written to me

Three-toed sloth holds to the top of a stump and surveys its surroundings for possible food, left. Mother and infant sloth are carefully moved to safety by rescuers, right, while another is lifted cautiously from water on an oar, below.

Drenched opossum has climbed an isolated tree in searc[h] for safety while fleeing inundation of its former island home

Bush Negro takes a captured armadillo to camp from dugou[t] canoe used in the I.S.P.A.-sponsored Surinam aid operation



Two members of rescue squad swim in pursuit of a deer that has been driven into water by hunters and their dogs.

Deer is guided by one of the staff to the side of canoe where other members of party will aid in lifting animal aboard.

John Walsh of Massachusetts S.P.C.A. helps hold deer while its legs are tied to prevent injury on trip to mainland.

as Chief Administrator of the I.S.P.A. (Western Hemisphere). With John Walsh of the Massachusetts S.P.C.A., I immediately flew to Paramaribo to have an emergency conference with a government committee.

After two weeks in the jungles, traveling to primitive villages in dugouts, locating islands formed by the floodwater, and generally assessing the terrain, we decided that it was expedient to hire Bush Negro inhabitants of the area as the main personnel for the operation. Since the language barrier was an additional difficulty, it was necessary to have an interpreter. In the local dialect the original name of the project was *Tjali Oedi Gwamba*, meaning "pity the poor jungle animals," which later was shortened to Operation Gwamba.

Our initial step was to map the islands, which were extremely difficult to locate. The men had to climb trees to spot the green vegetation that betrayed the presence of the islands, which were surrounded by dense, dead, gray trees and bush. Finding the mainland shore was nearly as hard. It took hours of probing through the in-

undated forest to locate it; then many more hours to cut through with machetes to make the paths that were used to release the rescued animals.

Rescue procedure varied. Larger animals, such as deer, ocelots, jaguars, and peccaries, were chased from the islands into the water by two local professional hunters and their dogs. Bush Negroes in motorized dugouts were strategically placed around the islands, and when an animal took to the water, they pursued it. Upon reaching the animal, the men leaped into the water to capture it, then lifted it into the boat and tied it with rope made of nylon stockings donated by women of the United States. Many of the arboreal animals, such as tamandua and silky anteaters, porcupines, opossums, and monkeys, were found in trees left standing on islands already under water. The men paddled their dugouts among the trees, and when an animal was found, they climbed the tree to dislodge it or cut the tree down and picked the refugee up from the water.

Among the many other animals rescued were armadillos, pacas, tapirs, kinkajous, lizards, and snakes, in addition to domestic cats and dogs left by the villagers whose towns were inundated. Many hundreds of two-toed and three-toed sloths were also found in the trees, starving from lack of fruit and the leaves and buds of *Cecropia*, which comprise most of their diet. In many cases the sloths, brought down and placed in sacks, were too weak to be released, and were put into a hospital compound until recovered.

Snakes, especially the aggressive and poisonous bushmasters, proved to be a problem. As the water rose, they—like the other animals—were crowded into increasingly smaller areas. Also, animals trying to swim to the mainland were seriously endangered by the piranhas in the waters surrounding the islands, as were the men who were forced to take to the water in the rescue process.

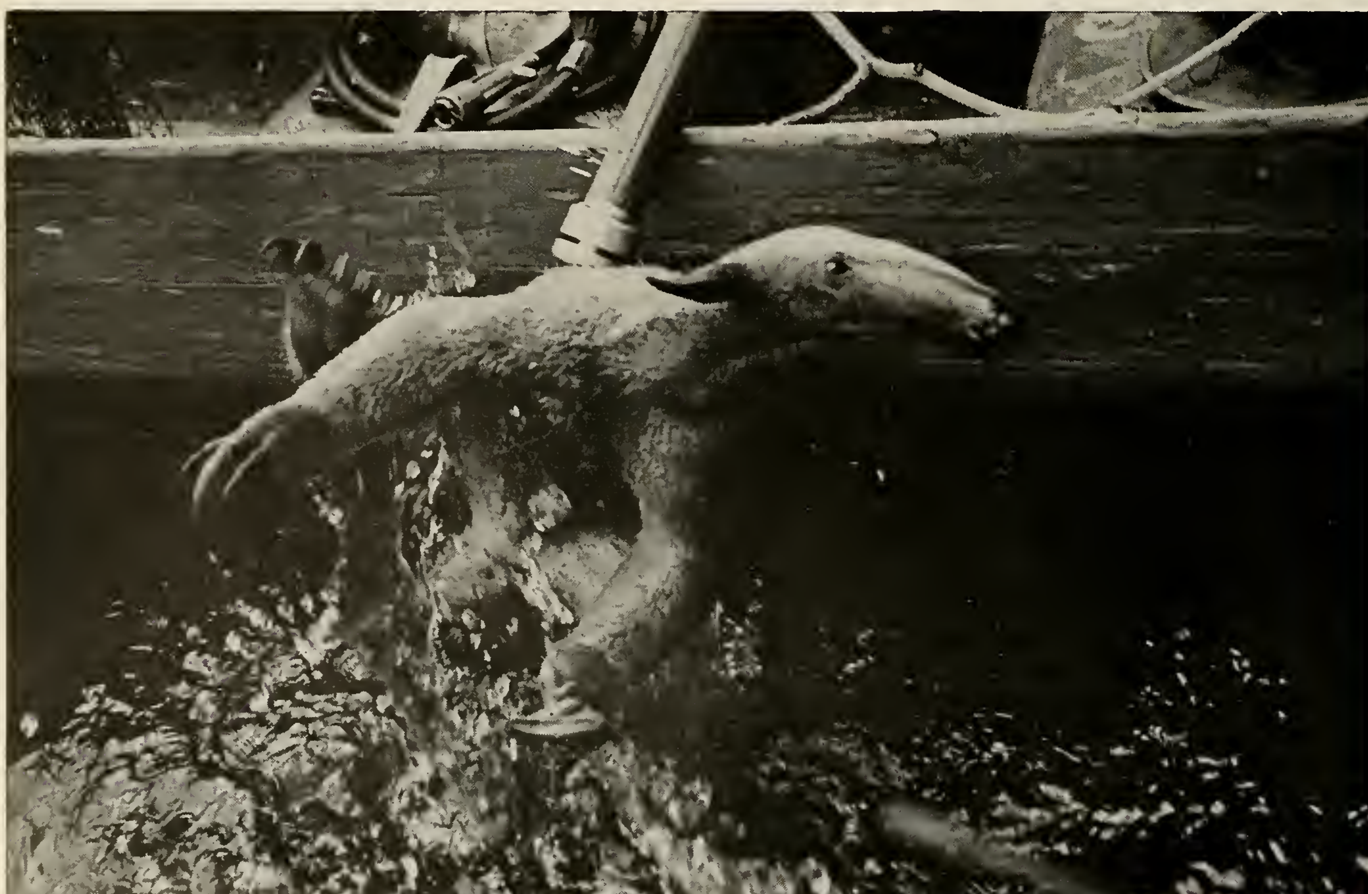
Most of the supplies for the project were sent from the United States—cages of all sizes, tranquilizer guns, animal control sticks, first-aid kits, and a supply of antivenin to be used in case of snakebite.

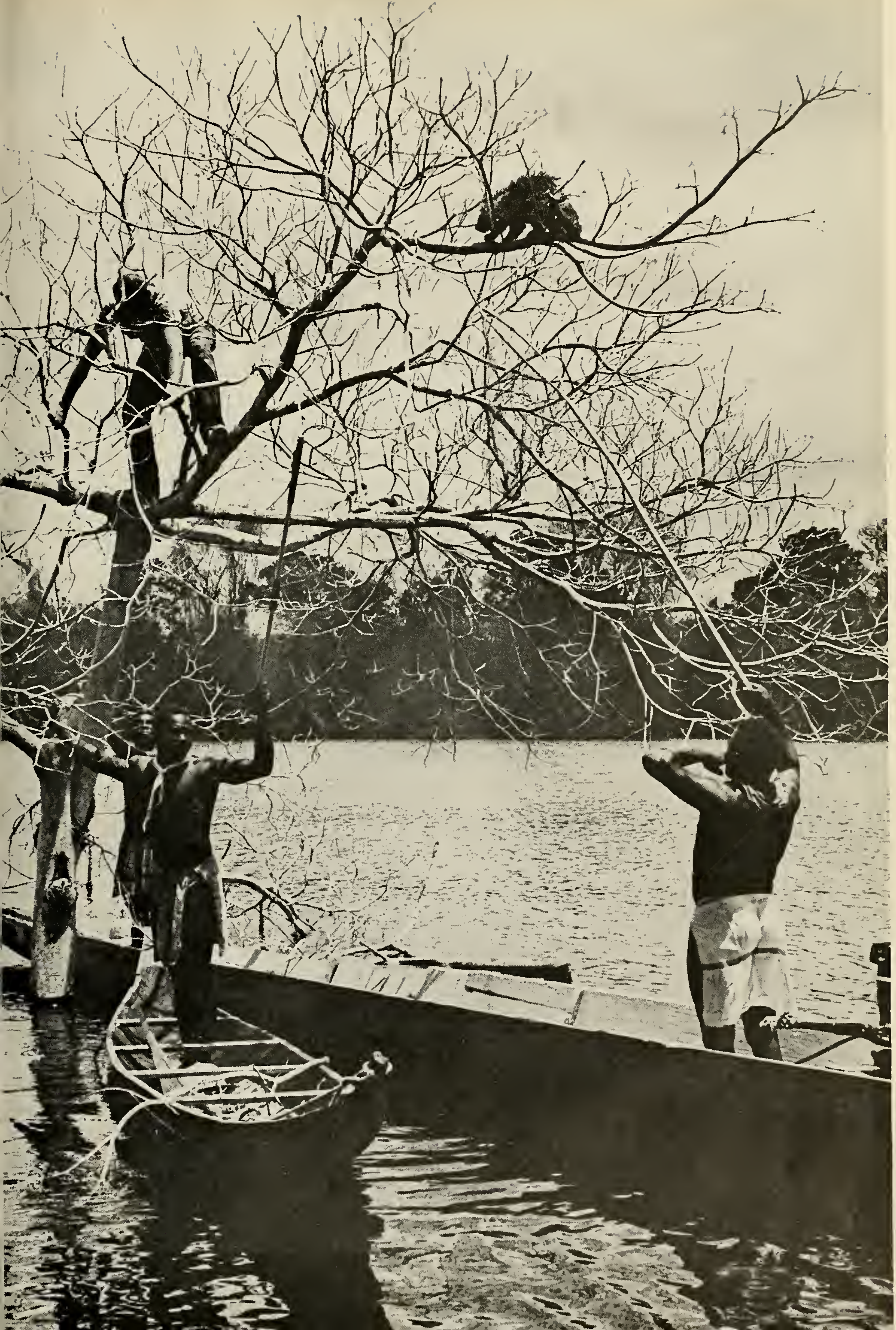
To date, over 8,000 large animals have been rescued through the effectiveness of the I.S.P.A.'s Operation Gwamba, and the work will continue at least through January, 1966.

Arboreal animals such as porcupines were dislodged from trees, right, which were sometimes felled for the purpose.

Treed by the flooding in Surinam dam construction, tamandua clings to branch, above, peering at rescuers and camera.

Tamandua is retrieved from the water by Operation Gwamba personnel using rubber noose on the end of a long pole.

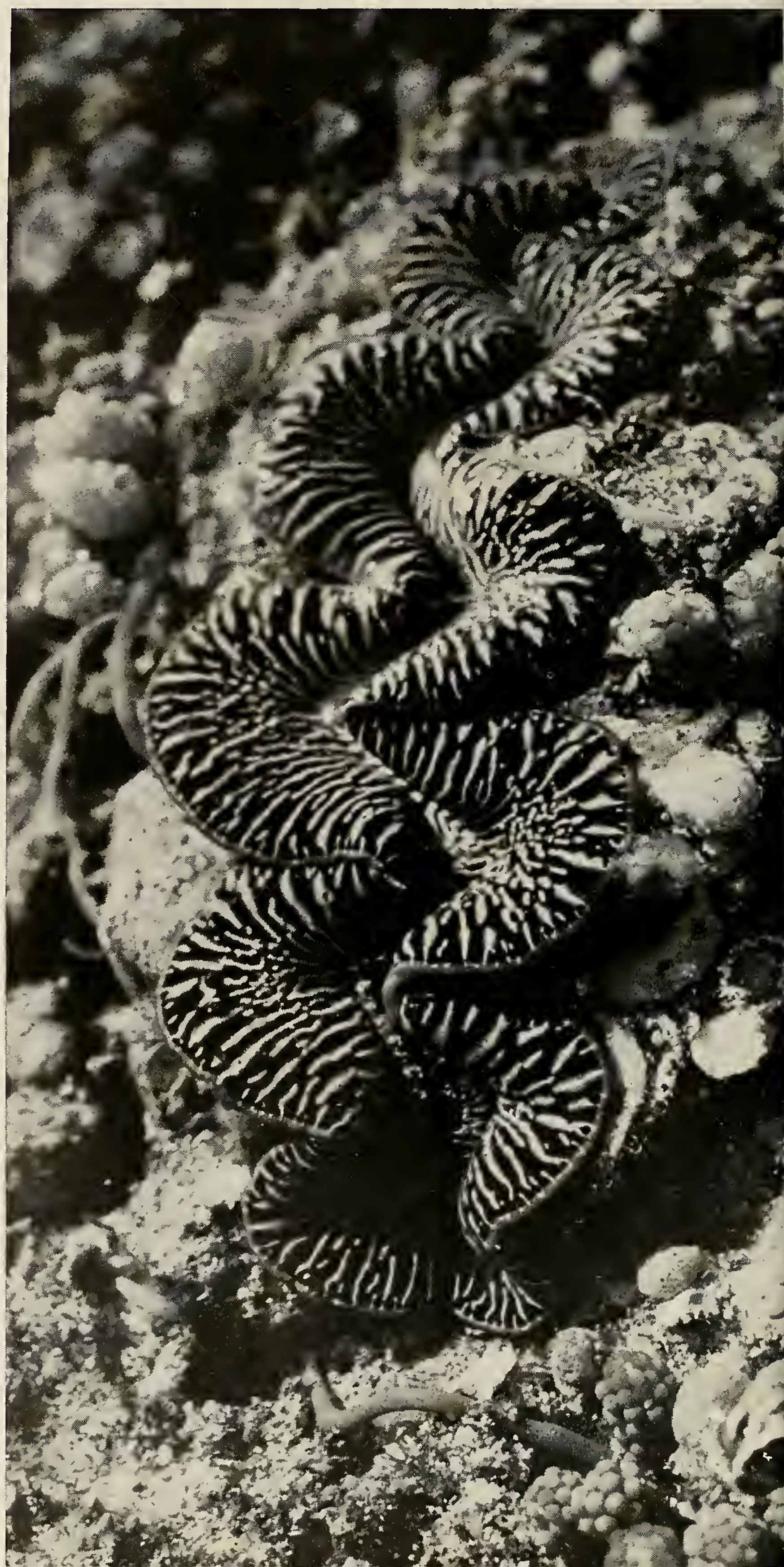




Myriad Colors in Coral

Life forms on the Great Barrier Reef are best seen at low tide

By Bruce Hunter



The Great Barrier Reef, lying from thirty to one hundred miles off the northeastern coast of Australia, is the longest series of coral reefs in the world. It stretches for 1,250 miles from Torres Strait, which separates Australia and New Guinea, to the Tropic of Capricorn. Some of the individual reef formations rise 6,000 feet from the ocean floor, and others are far enough apart to permit the passage of seagoing vessels. The reef is visible only at low tide, and with the rising of the sea even coral boulders on top of the reef are submerged.

Before one can explore the Great Barrier Reef, the sea must be calm, the tide must be low (preferably the low of the spring tide, which occurs twice monthly at new and full moons), and there should be no breeze to disturb the water's surface. The reef is about thirty miles from the nearest islands, and even with careful planning one cannot manage more than a two-hour inspection on the surface before the tide again rises to cover the coral. Lindeman Island, approached by plane from the mainland town of Mackay, is one point of departure, although it may be necessary to wait several days for favorable weather. When conditions are suitable, the journey to the reef is made by cruiser and then rowboat.

The reef crust looks flat and gray from a distance, but closer inspection reveals the dramatic colors of several hundred species of living corals. Also, just below the surface of tide pools shaped by irregular masses of coral, plants and animals range in color from emerald-greens and cobalt-blues to brilliant golds, pinks, and violets. Every footstep crushes down on the coral, and startled fish and crabs scurry away in the network of trapped tidal water, which ranges from a few inches to over a foot in depth. Sea urchins, starfish, and bêche-de-mer, or sea cucumber, move slowly across the bottoms of the pools, where many

IF EXPOSED to the air for too long, mass of staghorn coral, *above*, will die. Reef appears flat and gray from a distance.

EMBEDDED in dead coral, at the left, a nine-inch-long clam, *Tridacna fossor,* leaves its zebra-striped mantle exposed.

BRAIN CORAL, a stony coral that contributes measurably to reef construction, grows in many tide pools on the reef.

species of mollusks, such as the abundant, poisonous cone shell, *Conus marmoreus*, are also clustered.

There are many starfish on the reef, but none with the distinctive color of the ultramarine *Linckia*. This vivid and beautiful animal, often seen clinging to dead algae, is sometimes found on the underside of coral boulders, which are large masses of dead coral that have been tossed on top of the reef by the sea. A great number of algae may also be found, among them the conspicuous sea grape, *Caulerpa racemosa*, which grows in profusion among the corals in the tide pools and looks like clusters of green raspberries. The calcareous *Lithothamnion*, another alga, is colored delicate shades of pink and orange, and looks rather like the eroded coral over which it grows. When overexposed to the air, it dies and turns white, and plays an important part in reef construction.

When one first glances over the reef, it is difficult to imagine the life processes of a single coral polyp, or animal. A colony houses hundreds of separate polyps, each with a protective skeletal wall formed by a secretion of calcium carbonate from the animal's outer "skin." Despite its seeming delicacy, the polyp is stimulated by strong surf, and a reef community thrives best in strongly agitated surface waters. Each polyp is male or female, and reproduces by eggs and sperm. The egg is fertilized outside the polyp, develops into a planula larva, and then floats in the sea for a short time before attaching itself permanently to part of the reef mass. Here it reproduces by branching and budding, and in so doing continually forms new colonies.

The corals are coelenterates, and are not too different in structure from the sea anemones commonly seen along North American shores. The coral polyp is jelly-like and pliable, and muscle bands around its body cause it to expand and contract. It is cylindrical and attached at one end to the coral colony, while the other end is flattened and contains the oral disk, or slit, used for feeding and excretion. It feeds on plankton, which are microscopic animal and plant forms that remain deep in the ocean in daylight and move toward the surface at night. When food is within the polyp's reach, tiny threads that form part of its sting cell are ejected to stun the prey, and tentacles around the opening act like arms to seize, hold, and push food into the mouth. The tentacles contract when not in use, and are usually not visible.

Brain corals and star corals are widely distributed on the Great Barrier Reef and make up the more solid masses of reef construction. Brain coral, which has a wide color range, grows in spherical masses much like the shape of the human brain, with the polyp colonies forming elegantly convoluted ridges and valleys. When low tides expose them to air and sun too long, the domes of these colonies die, leaving a base outer ring that continues to grow higher, often causing the formation to resemble a basket. The dead central bed then becomes the home of small clams, crabs, and algae. The star corals are vividly colored, ranging from straw-yellows to blues, and from emerald- and grass-greens to purple-browns. Since they are night feeders, as are most corals, their polyps are contracted during the day. As a result, much of the color in the tide pools depends on the coral's limestone structure rather than on the varieties of colors of the polyps.

Large, massive corals, such as the star and brain corals, are apt to be found on the more exposed, seaward side of the reef, while more delicately structured corals colonize in pools and on the more sheltered side. The beautiful staghorn coral, *Acropora*, in shades of heliotrope and blue, can be seen in many varieties. On the seaward side of the reef it becomes heavy and thick and grows to several feet, often resembling the limbs of great trees. In tide pools, however, where the sea is calmer, more delicate varieties of staghorn grow to only a few inches.

Looking more like seaweed than any other coral, *Lobophyton*, which forms in colonies several feet across, is one of the soft corals that abounds in many sections of the reef. It is a large, flabby mass with soft, spongy, branching fingers that range in color from dull olive-green to various shades of ocher. The soft corals are in contrast to the stony corals, such as the brain corals and staghorn corals, which have a rigid limestone construction.

Embedded in the coral on the reef is the giant clam, *Tridacna gigas*, which is often considered the largest known shellfish and may reach four feet in length and weigh as much as five hundred pounds. A smaller variety, *Tridacna fossor*, is more common. These clams, often referred to as "frilled clams," are usually not over ten inches long. They burrow into the dead coral, and leave exposed only the beautiful fleshy mantle that surrounds their mouths. Like the corals, the *Tridacna* have algae, which contribute some part of their nutrition, living within the tissue of their mantles. There are still many questions on how this symbiotic relationship functions, but much of the color of the clam's mantle is believed to come from the algae. The mantles of the clam have a variety of designs—some are zebra-striped and spotted; others are solid.

The foundation of Great Barrier Reef has been constructed, for the most part, by massive, stony corals. Calcareous algae, too, with their secretions of calcium carbonate, have been important in the cementing action. Along with these reef builders are many other forms of marine life that add to the skeletal wall. One of these is the foraminifera, or "pore-bearers," so called because of the perforations on their shells. They are amoeboid protozoans with protective skeletons of calcium salts, and they contribute substantially to reef construction.

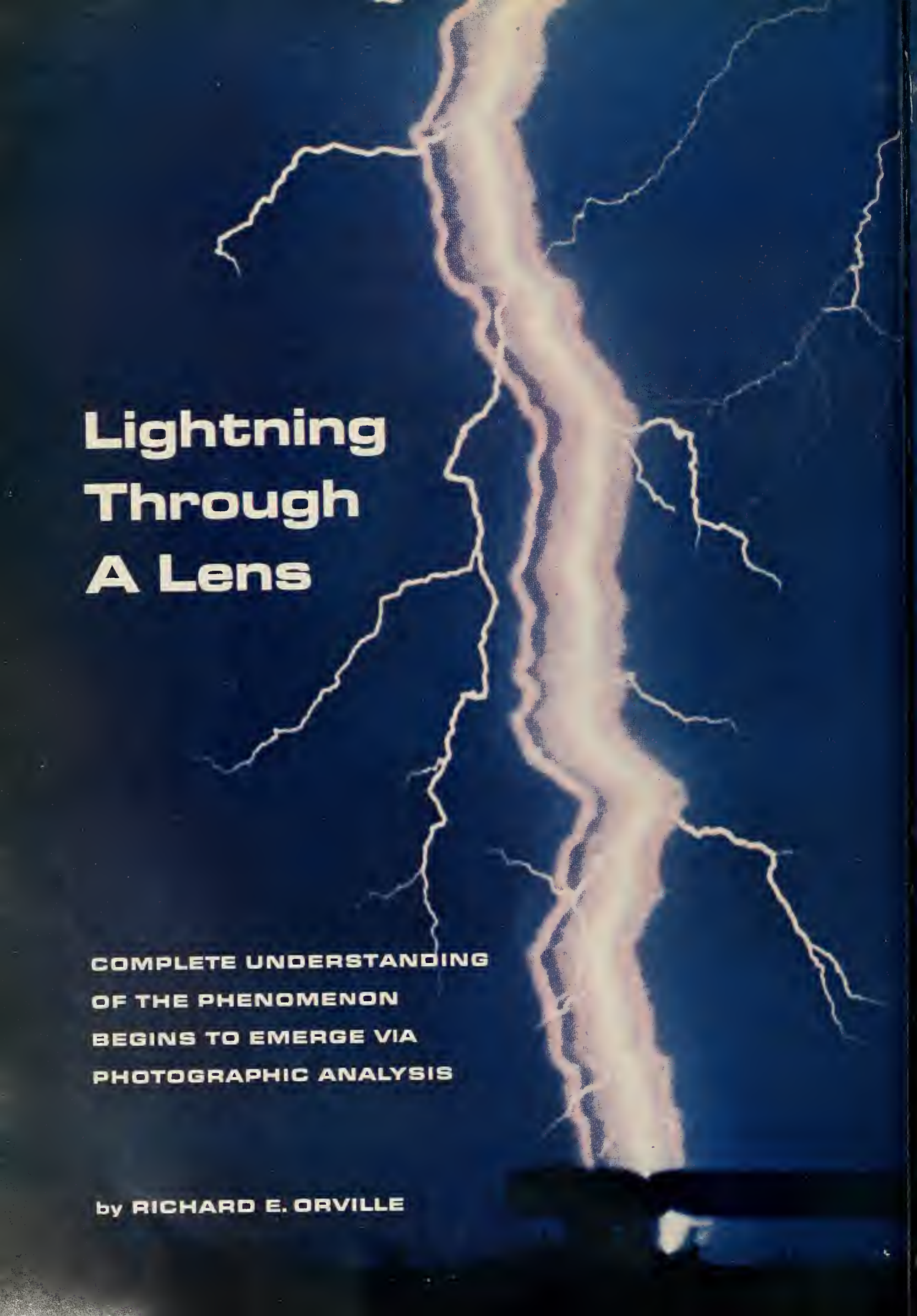
While reef building is in process, destructive forces also play a role in the long history of a reef. Some of these destroyers are burrowing worms, clams, mussels, and barnacles. The sea and the weather, too, often damage the reef. Boulders of coral weighing several tons have been torn from the reef edge and hurled high on the crest.

Visitors leaving the Great Barrier Reef inevitably plan to return, because little can be seen in such a frustratingly short time. Tide pools far down the reef, holding hundreds of coral species, wait to be explored. Protected by an outside rim of the hardiest corals and algae, which continues to build and rebuild, thousands of plant and animal communities survive on the reef in countless ecologic niches.

BLUE STARFISH, *Linckia*, moves along bottom of tide pool, *above*. The green alga is *Caulerpa racemosa*, or sea grape.

POLYPS are contracted, *right*, in a colony of hard coral, *Stylopora palmata*. Rosy color is from the skeleton itself.

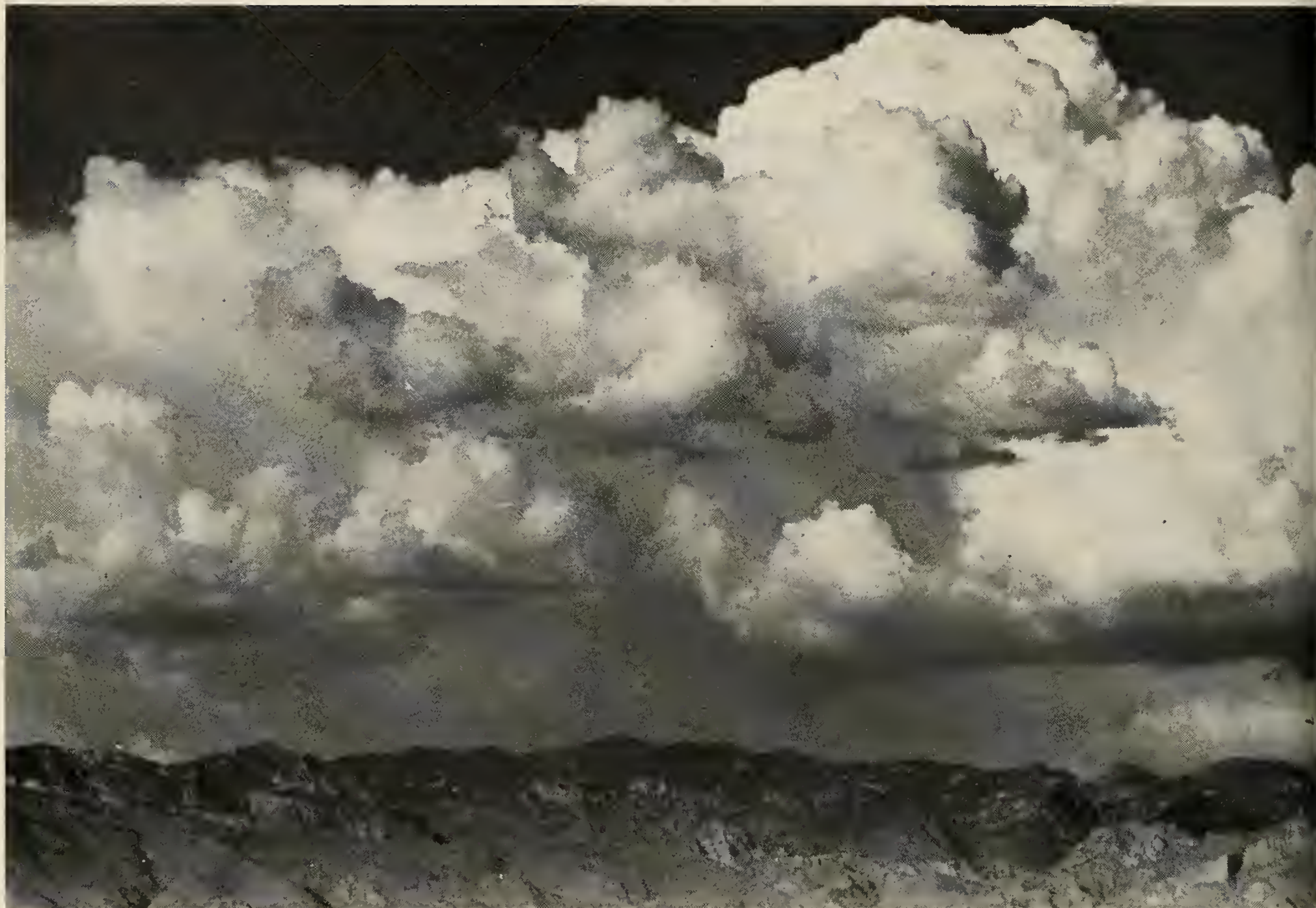
EXTENDED polyps give purple color to a poritoid coral. The algae nearby are orange *Lithothamnion* and green sea grape.



Lightning Through A Lens

COMPLETE UNDERSTANDING OF THE PHENOMENON BEGINS TO EMERGE VIA PHOTOGRAPHIC ANALYSIS

by RICHARD E. ORVILLE



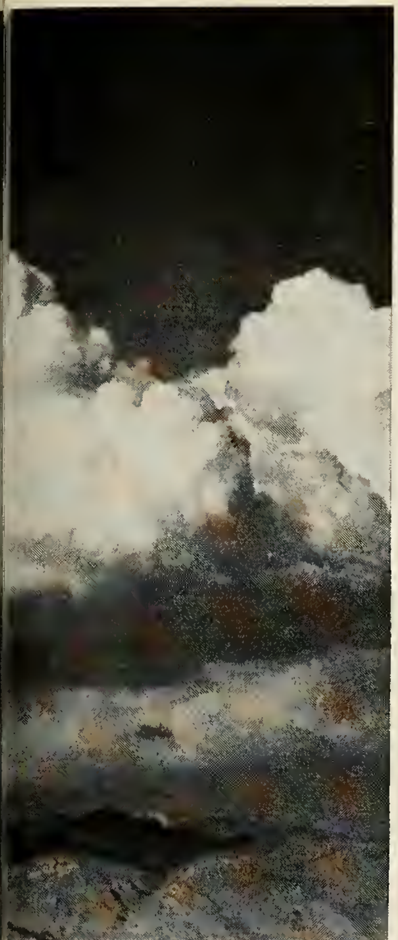
Growth of cumulus clouds in afternoon frequently produces evening lightning.

Four separate flashes are seen in this dramatic display over Tucson, Arizona.

The mythology of past generations supplies ample evidence that lightning has always been deeply respected. Much that has been written about the phenomenon indicates the intertwining of truths and untruths in men's minds; only in comparatively recent years has science begun to attack the subject. Time, patience, and careful techniques are leading gradually to a detailed description of the lightning flash. At some time all of us have asked, "What is lightning?" and "How is it produced?" Perhaps we have also wondered about its physical characteristics. Today, these questions are implicit in a variety of basic research programs, whose purpose is to obtain photographic records of the lightning discharge and to supplement them with simultaneous electrical studies. All this information must then be correlated with laboratory studies of the passage of electricity through gases. Through these extensive efforts a model of the lightning flash is beginning to emerge. In the following discussion we will limit ourselves to describing some of the results that have been obtained from photographic studies of lightning.

It is interesting that some of the earliest photographs of lightning were taken by astronomers. These were not always typical black-and-white pictures, but rather were spectroscopic recordings of the intense discharge. They were obtained by mounting a transmission grating or a prism in front of a camera, setting the lens to time exposure, and waiting for a lightning flash. The results were similar to the accompanying photographs, but without the detail in the current spectra. Astronomers are interested in observing lightning because studies allow them to separate the spectrum of a lightning flash from that of the aurora or of the nightglow—either of which may appear during many hours of exposure. It is necessary to separate the spectra if that of the aurora or of the nightglow is to have any meaning.

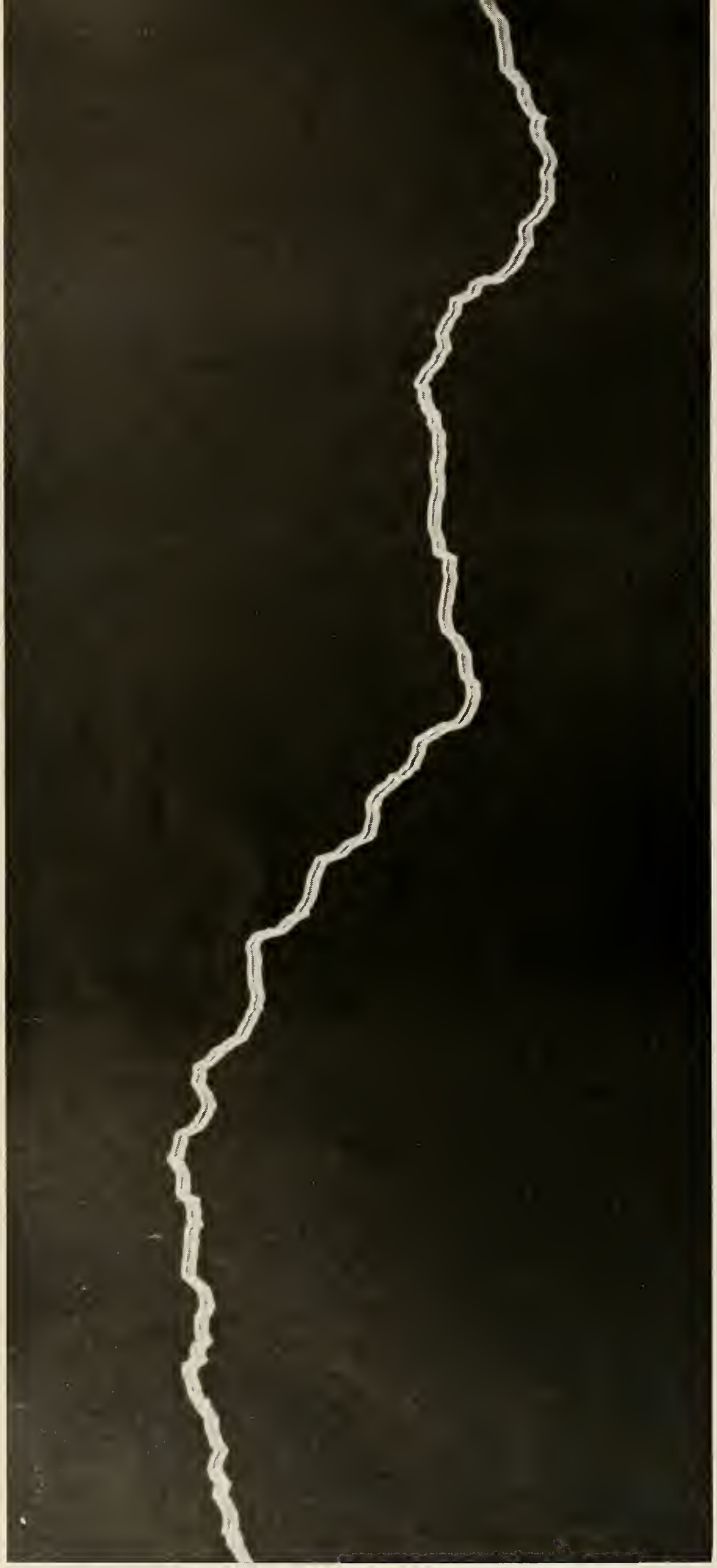
In later studies of lightning, high-speed cameras were used to separate the various components of the light-



ning flash. Here there was a choice between a fixed lens and revolving film, or a moving lens and fixed film. The results of the studies tell us that the visible cloud-to-ground flash may be composed of several processes called strokes. These strokes, in turn, consist of a leader process, which establishes a short circuit between the cloud and the ground, and the return stroke, which is the flow of current through the short circuit. It is the brilliant return stroke that we see, as the leader process is far too faint for the eye to detect.

But what causes these intense discharges between the cloud and the ground? Studies of the electrostatic fields of cumulo-nimbus clouds indicate that the cloud top has a predominantly positive charge, and the base has a predominantly negative charge. During the electrification process, opposite charges, produced on different cloud particles, are separated to produce predominantly positive and negative regions in the cloud. When the increasing electrical charge exceeds a critical value, beyond which the air can no longer contain the charge, the air will "break down," and current will begin to flow. This flow of current (the lightning stroke) may occur within the cloud, between clouds, or between the cloud base and the ground. It is this last process that is of particular interest to us.

From the negative charge region in the cloud base, a faint, luminous channel, or stepped leader, proceeds in steps toward the ground. After each step, which averages fifty yards, there is a pause before the channel continues its tortuous path downward. At the beginning of each step, branches or forks may form and continue in their steplike pattern toward the earth. An ionized path is formed in a few thousandths of a second by this stepped leader, much too fast for the eye to see, but clearly resolved on film by high-speed cameras for later analysis in the laboratory. The point actually struck by lightning is determined only in the last one hundred yards or so, when the stroke is near the ground, and the short circuit between the cloud and the ground is nearly complete. The channel contains a large number of free electrons in its ionized path. When electrical contact is made with the ground, the return stroke begins, and electrons flow rapidly toward the ground, like water from a bathtub drain. The electrons nearest the ground move first, and then others cascade down from higher and higher levels. Similarly, the brilliant luminosity of the return stroke streaks higher and higher toward the cloud base at one-third to one-tenth the speed of light. This is the heavy current phase that we see, and the consequent heating and expansion produce a shock wave that we hear as thunder. In approximately one ten-thousandth of a second the stroke is completed. Leaders of subsequent strokes pass smoothly down the preionized channel. The light is intense at the tip, and a high-speed camera records a dartlike spot of light—the dart leader—passing down the channel. Again the return stroke occurs. This leader–return stroke process may be repeated ten or more times and be perceived by the observer only as a flicker. If a strong wind is blowing across the line of observation, the channel of subsequent discharges is displaced, and produces the phenomenon that is commonly referred to as ribbon lightning.



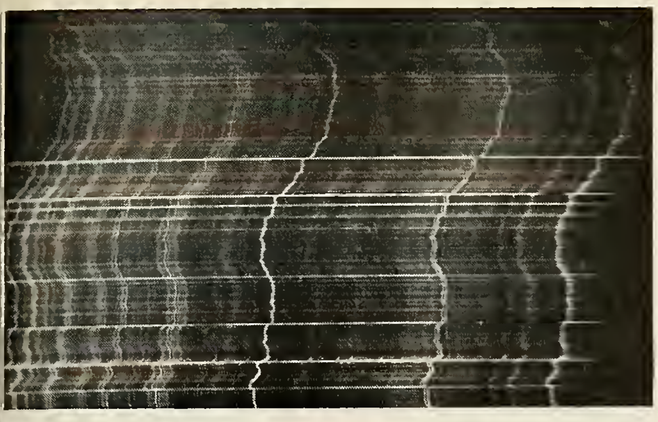
Ribbon lightning takes its name from an effect created by strong winds that blow across point of observation and displace the successive strokes in flash.

Brilliant displays of lightning in Tucson, Arizona, recently prompted Leon Salanave, a research associate with the University of Arizona's Institute of Atmospheric Physics, to revive the technique of recording slitless spectra of lightning. This is accomplished, as I mentioned previously, by mounting a transmission grating in front of a camera. The lightning flash serves both as the source of light and the slit. The resulting spectral lines are the image of the channel itself. Thus it is possible to study not only the characteristic emissions from the flash but also the variations in temperature and density along the channel.

These techniques have produced over three hundred slitless spectra on high-speed black-and-white film; two examples are reproduced on page 39. Note that the spectrum of the entire flash has been reproduced in one case, whereas the other is the result of isolating a section of the lightning channel in the focal plane and then rotating the film. The result is a spectrum of the flash, time-resolved into its component strokes.

The same qualitative data can be obtained on color film, but are inadequate for quantitative analysis. Nevertheless, the recent introduction of fast color emulsions and the availability of inexpensive replica gratings bring the technique of slitless spectroscopy of the lightning flash within the range of the amateur photographer. The first color spectrum of lightning is reproduced here. I obtained it by mounting a transmission grating (13,400 lines to the inch) between two pieces of glass and using it as a filter on a 35 mm. camera with a 50 mm. lens. The photograph will clarify the following step-by-step description.

On August 8, 1964, an intense thunderstorm, with continuous rain and winds estimated at 30 miles per hour, approached our lightning observatory, located a few miles east of Tucson. My camera was loaded with Kodachrome II Daylight film, the aperture was opened to f/4, and the shutter set on time exposure. After about 15 seconds, a lightning flash occurred approximately 1 km. from the tripod-mounted camera. Intense light from the flash silhouetted the guardrail in the foreground and en-



Extensive line identifications have been obtained from black-and-white spectrum of a flash of single or of many strokes.

When lightning channel section is isolated by spectrograph, a time-resolved spectrum is acquired by rotating the film.

tered the transmission grating, where it was split into its component colors, or spectrum. (The appearance of a spectrum is the result of an interference phenomenon of light, which occurs whenever you see a rainbow.) A transmission grating has the property of passing most of the light straight through—like an ordinary sheet of glass—while the remainder is sorted out into spectra on either side of the undeviated beam. The latter produces what is called the zero order of interference; immediately to the right and left of this are found the pair of first-order spectra, or first order of interference. Spectra of higher orders are found still farther from the undeviated beam (zero order) and are much fainter. The zero and first orders were focused by the lens onto the film, where the images were recorded for our qualitative analysis. Luminous branches from the lightning flash were too dim to yield spectral images, and therefore only the spectrum of the main channel appears on the right. We immediately note the wide range of color, from deep blue to two strong red lines, and the curious absence of any yellow. At various points in the spectrum, streaks appear, and in the blue region are two faint, white lines that seem out of place in this ordered arrangement of color. At the left, the brilliant lightning channel is paralleled by three satellite lines. Two of these lines are symmetrical along the main channel and show a slight color dispersion across their diameter, while the third satellite line shows no color dispersion across its diameter. From previous work I have done with the slitless spectrum of lightning, I have discovered that it is now possible to identify all of these curious features.

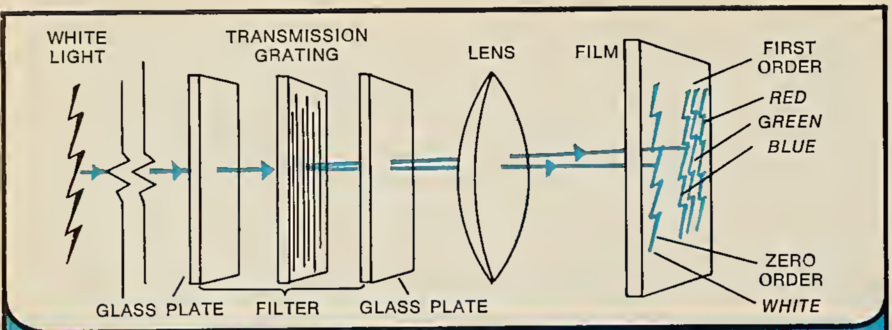
The principal constituents of our atmosphere are nitrogen, oxygen, and water vapor, which is composed of hydrogen and oxygen atoms. Therefore, it is not surprising that an intense electrical discharge in the atmosphere produces a spectrum with emission lines from these elements. For example, the most intense red line in the spectrum is the so-called H-alpha line, attributed to hydrogen atoms derived from the dissociation of water molecules in the path of the lightning flash. Dissociation results when the high current in the return stroke supplies the necessary energy to split the water molecule into its component parts—two hydrogen atoms and one oxygen atom. These will then emit light that is characteristic of their species.

Dissociation also occurs to the nitrogen and oxygen molecules. At higher energies, each atom loses one electron, and we then see characteristic lines of singly ionized oxygen and nitrogen atoms. Indeed, most of the lines in the slitless spectrum of lightning, and all the lines to the left of the intense red line, are attributed to the singly ionized state of these two elements. Our atmosphere filters out more of the blue and green lines than the yellow and red, and, therefore, distant flashes on the horizon frequently have a reddish color. (This is exactly the same phenomenon that makes the setting sun appear red.) These flashes are too far away for their thunder to be heard, and when observed under clear skies on a warm summer evening are called heat lightning.

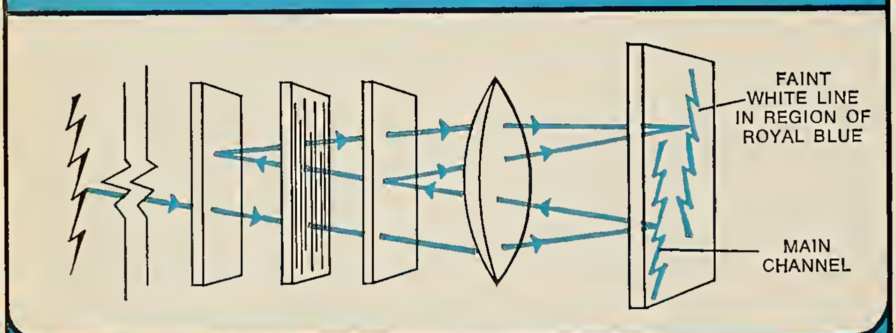
The only remaining features to be explained in the spectrum are the horizontal streaks occurring at various points along the channel. Recent studies indicate that there is a continuum existing throughout the optical spectrum at all heights in the channel. At points where the stepped leader process described above has led the channel horizontally for a short distance and, by chance, also directly toward or away from the observer, the exposure is intensified, and we observe the characteristic lightning streaks. Every slitless spectrum of lightning shows this feature.

An explanation for the two faint white lines in the region of blue is found in the overexposure of the main channel. Now recall that the transmission grating is mounted between two pieces of glass for protection and is then attached to the camera lens. The intense zero-order light passes undeviated through the grating and produces an overexposed image and several multiple images. Some of this light is reflected from the film, and returns through the lens to the glass protection plates. Here reflection again occurs from the respective plates, and two faint inverted images are recorded in the blue region. The lines do not have the same intensity because the light has passed through more glass in one case than in the other (*drawings, page 40*).

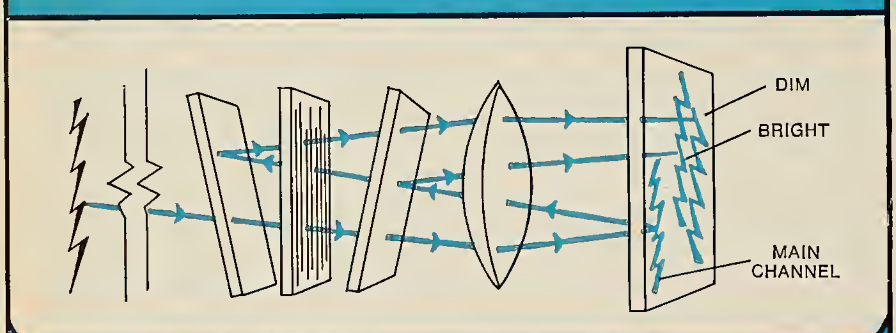
Around the intense zero-order image in the color picture are two channels left of the main channel and one on its right. The distribution is obviously asymmetrical. The two satellite lines, which are symmetrical about the main stroke, show a slight color dispersion across their diameters—from blue to red as one looks away from the main stroke. This set of satellite lines is therefore associ-



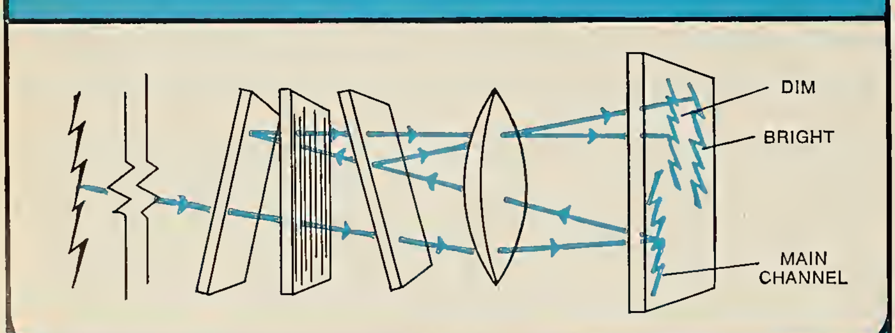
White light of a flash is split into its various orders when going through a filter consisting of a transmission grating, ruled with thousands of lines per inch, between glass. Light is then focused by the lens onto film plane.



The rays reflected from the glass are exactly parallel providing the pair of glass plates is also parallel, therefore, the rays focused by the lens to form a single, faint, and inverted image are in spectrum region of royal blue.



If the glass plates are not parallel, the light rays reflected from them will not be parallel, and will cause two inverted images of main channel to be focused on film by lens. Brighter image is then closer to main channel.



If glass plates are not parallel and are slanted in the opposite direction, two inverted images of the channel will be formed with the bright image farther from the main channel. This is illustrated in the color photograph.

ated with diffraction effects. They are false lines with a symmetry in spacing and intensity. This phenomenon is caused by a periodic error in the ruling of the grating lines and is characteristic of inexpensive gratings. Because of the lines' low intensity they fail to show up in the first-order spectrum. This explains two of the three satellite lines. The remaining line is the result of an internal reflection from the main channel image.

It should be emphasized that this color photograph contains only the qualitative features studied previously on superior black-and-white spectra. For example, a study of the relative intensity of singly ionized nitrogen lines has made it possible to estimate the temperature of several strokes in a flash. Values on the order of 45,000°F., or more than four times hotter than the surface of the sun, have been obtained. Further analysis tells us that the pressures within the stroke reach twenty to fifty times the normal atmospheric pressure. But the corresponding density of this incandescent gas is only about one-fifth that of air at normal pressure and temperature. There has been a very rapid expansion and a very great rise in temperature; this gives the transient effect of a high pressure occurring in a gas of comparatively low density. We should keep in mind that previous measurements of the current in a lightning return stroke attain peak values of 20,000 amperes, with some reliable measurements as high as 200,000 amperes. (The fuses in our homes are set to break the circuit when the current exceeds 15 or 20 amperes.)

Studies are being continued to correlate these luminous emissions of lightning with their electrical characteristics in an effort to obtain a complete description of the lightning flash. It has been relatively easy to carry out isolated experiments on many flashes, but it has also been deceivingly elusive to operate many experiments on a few flashes simultaneously. In time, lightning will yield to these studies, and another step will have been taken in understanding nature's physical processes.

As stepped leader descends from the cloud base, forks may branch from it.

Predation's

ADÉLIE lunges at a South Polar Skua as it flies low near the penguin nest. Skuas prey on penguin eggs and chicks.

Impact on Penguins

Skua and Adélie predator–prey habits reflect long-term adjustments

By William J. Maher

A study of the predator–prey relationships between the South Polar Skua (*Catharacta skua maccormicki*) and the Adélie Penguin (*Pygoscelis adeliae*) reveals many interesting adaptations that have occurred in the two bird species. Predation is a complex phenomenon that affects the behavior and structure of both predator and prey, and is also presumed to affect the numbers of both populations. It is this latter aspect of predation—the short-term control of the numbers of each species—that engages the attention of many biologists. I spent the austral summer of 1960/61 at Cape Hallett in northeastern Victoria Land, Antarctica, studying the skua and the Adélie Penguin, and in this article I shall discuss certain long-term adjustments that both predator and prey appear to have made. I will then try to assess the impact of skua predation on the penguin numbers at Cape Hallett.

The South Polar Skua breeds in colonies around the edge of Antarctica as well as on snow-free mountain ranges some distance inland. It is a large bird, weighing about 3.1 pounds, and is similar in appearance to a large, brown gull. Indeed, it is considered to be a primitive relative of the gulls. The skua is partly a scavenger, but it also has predatory habits. It is usually the only bird seen flying in the bright daylight hours in the Antarctic and is particularly abundant around the Adélie Penguin colonies. Its predatory habits, boldness, and rich brown plumage, tinged with gold especially on the head, have led some biologists to compare it with the Golden Eagle.

The Adélie Penguin nests in colonies on the perimeter of Antarctica, and on a few islands just north of that continent, occupying the coastal land that is ice-free and accessible in the summer. Its nesting congregations range in size from a few thousand birds to enormous colonies estimated at almost a million pairs. The Adélie is not a large penguin—an average adult weighs 9.8 pounds—but it is about three times heavier than a skua.

Breeding side by side, then, the skua and the Adélie Penguin are closely associated, and probably every Adélie colony is exploited as a food source by a colony of skuas. Some small skua colonies and occasional pairs of skuas are associated with the colonies of other Antarctic birds, such as the Snow Petrel (*Pagodroma nivea*), but the Adélie Penguin is the skua's major food supply, and it is probable that the skua could not maintain itself in Antarctica if it were not for the Adélie.

Cape Hallett is a towering headland, 1,000 feet high, which forms the seaward bastion of Edisto Inlet and Moubray Bay (*see map, page 45*). The penguin and skua colonies occupy a forty-acre hook-shaped sandspit on the lee side of the cape. A ridge along the seaward shore has a maximum elevation of ten feet, and behind this there are a series of lower ridges and shallow depressions.

The South Polar Skuas, which numbered 181 pairs in 1960-61, nest in a loosely knit colony on the slope just above the penguin colony and on an adjacent area of low land. A few skuas also nest in depressions within the penguin colony. An estimated 60,000 breeding pairs of penguins nest on the ridgetops, usually avoiding the depressions, which are frequently flooded by melt water during the summer months. The penguin colony is thus subdivided into a number of discrete small units, or colonies, separated by unoccupied areas. Both the skua and the penguin display that fearlessness of man characteristic of many Antarctic animals that have no natural predators on land.

Adélie Penguins begin to arrive at Cape Hallett in the middle of October, having spent the winter months on pack ice to the north. Arriving birds hasten to territories used in previous years, and as a result the same pairs usually mate year after year (Natural History, October, 1962). Two eggs are laid two to three days apart, in late October or early November, and incubation by the male begins after the first egg is laid. The female returns to the sea to feed, and then, only a few days before the eggs hatch—some thirty days after they were laid—relieves the male, who goes to sea to break his long fast. The adults then take turns brooding and feeding the chicks, and after four weeks, when the chicks are half-grown, they begin to gather in groups called crèches. They are fed by the adults until fully grown. By early February, at nine weeks of age, the chicks gather at the edge of the water and make clumsy attempts at swimming. Finally, after gaining some proficiency, they swim to a nearby ice cake and then drift out to sea, where they will remain until ready to breed several years later. Adults leave the colony at about the same time, although a few remain and undergo their annual molt there, instead of on the ice.

The skuas arrive at Cape Hallett in the latter part of October, just after the Adélie Penguins. Like the penguins, they usually reoccupy their old territories and remate with their former partners. Two eggs are laid in mid-November, a day or two apart, and the sexes share equally in the 28-day incubation. Chicks begin to hatch in mid-December. Young skuas stay near the nests and are protected (sometimes from cannibalism by other skuas) and fed by their parents for six to seven weeks before they are able to fly. They are dependent on their parents for food for several weeks after this. Fledglings and adults begin to leave the colony in late February, and the young apparently do not return to the breeding colony until they are four or five years of age.

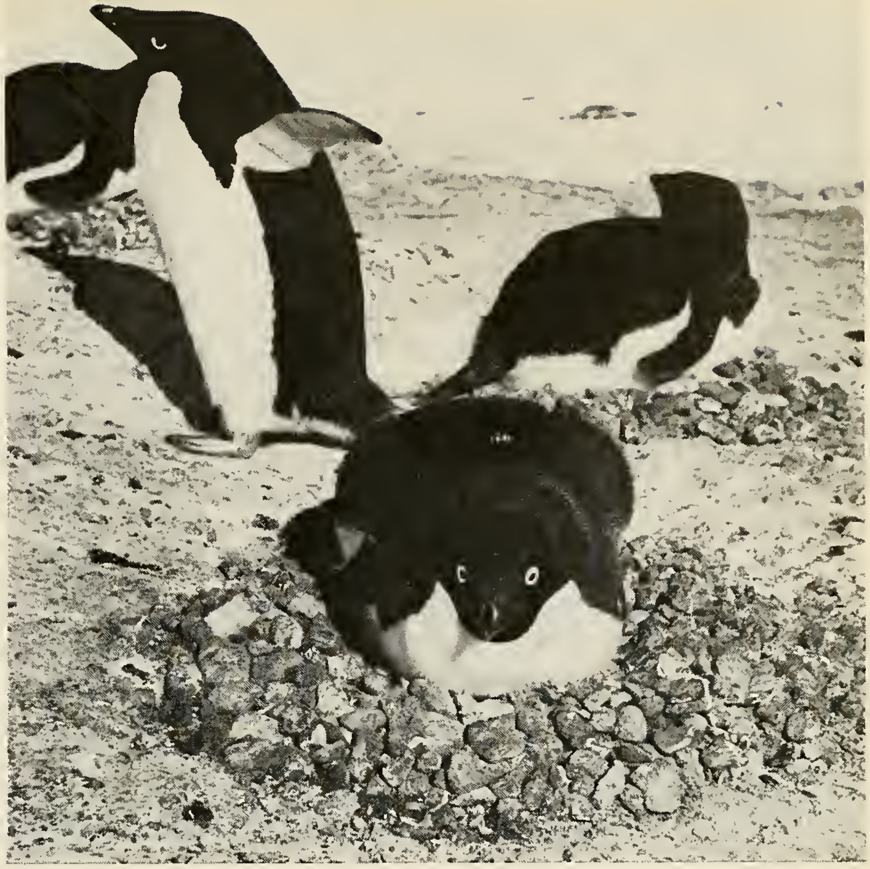
Many features of the skua's breeding habits and breeding schedule reflect an almost complete dependence on penguin populations. During the breeding season the skua's food consists mostly of penguin eggs, chicks,

Mates greet each other whenever the incubating bird is relieved at the nest.

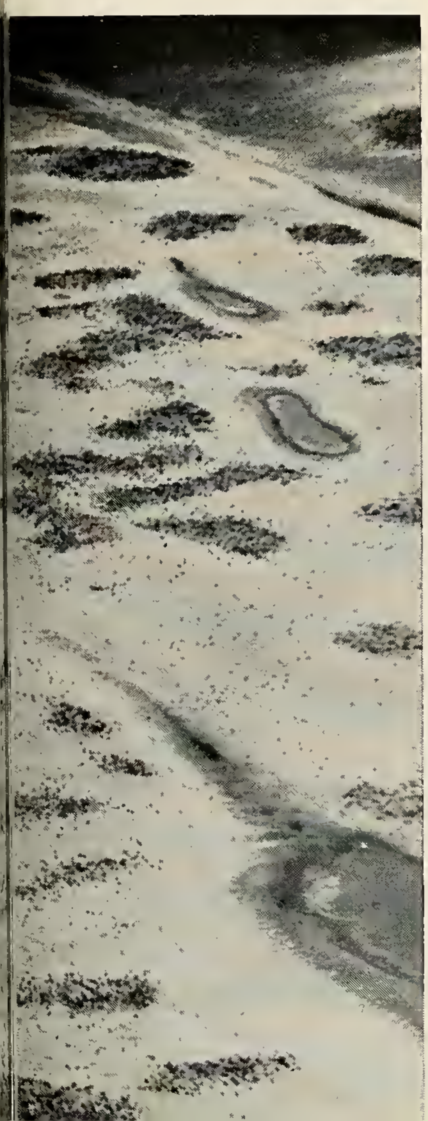
and dead adults. It also eats food dropped as the penguins feed their young on euphausiid shrimp and occasional small fish. Fish remains are found at some skua nests, and rarely, remains of Snow Petrels or Wilson's Petrels (*Oceanites oceanicus*).

Early in the breeding season, before the penguins have laid their eggs, the skua's food supply is extremely low. This may be, in fact, the most critical period of its breeding cycle. Its food at this time consists of whatever it can scavenge: the placentae of Weddell seals (*Leptonychotes weddelli*), which pup on the ice about the edge of Antarctica in October; a few adult penguins that die; and debris (consisting of penguin carcasses from previous years), which is exposed as the snow melts. Skuas have a large supply of body fat when they arrive at the colony, and it is possible that they depend to a large extent on their fat re-

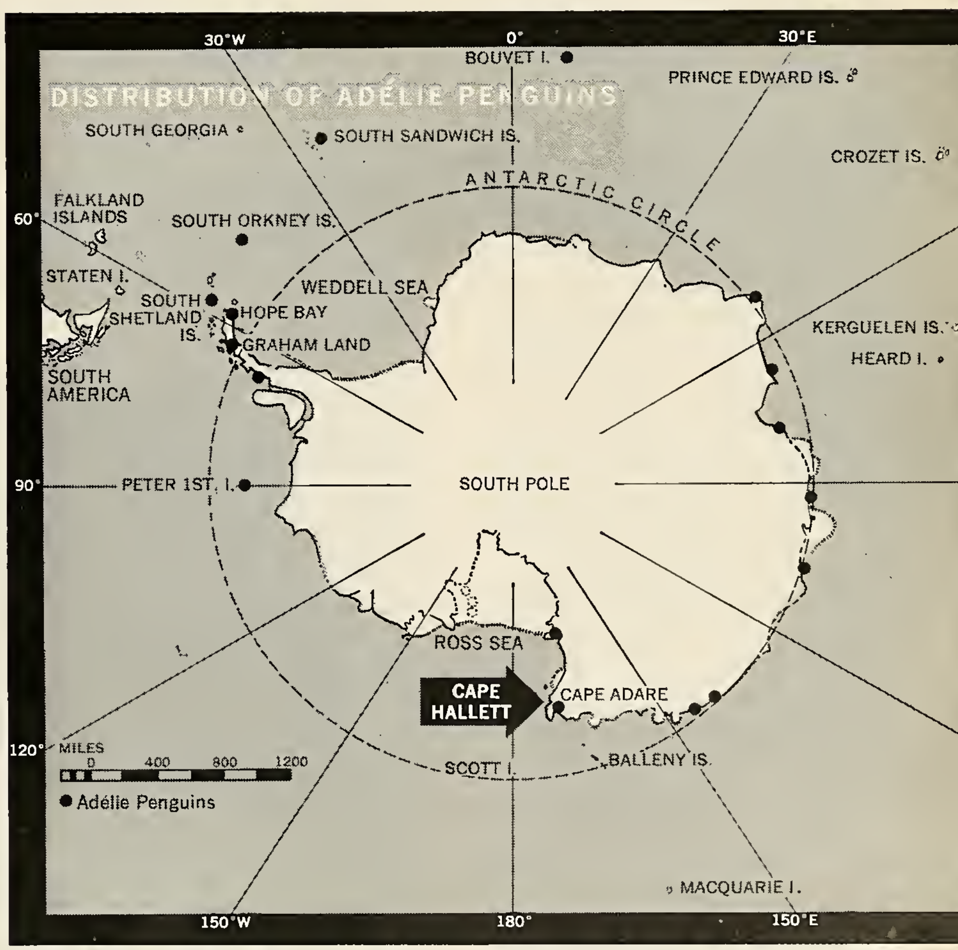
Adults sit closely on eggs to protect them from skuas and the extreme cold.



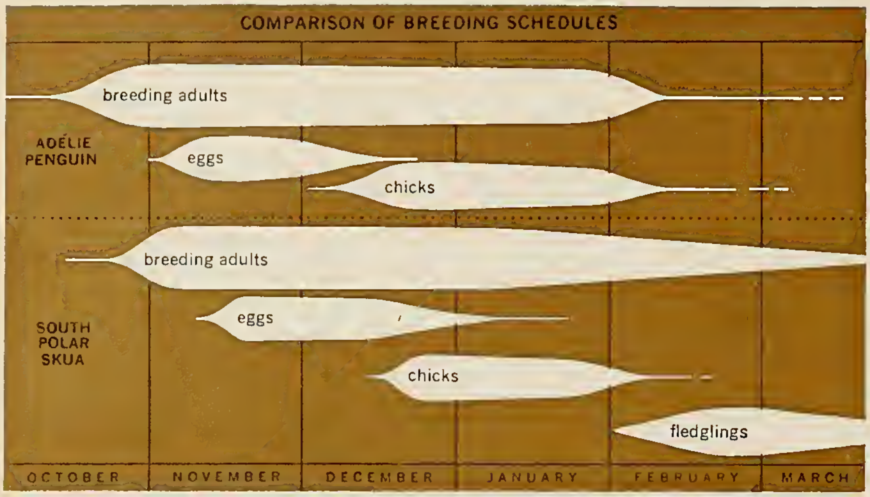
erves to sustain them in this period.
Skuas prey on penguin eggs during he egg-laying and incubation period, ut the penguins cover their nests losely and the eggs are relatively unvailable. Penguin chicks are similarly navailable until they begin to move way from their parents and form rèches. But as the summer advances nd the penguin chicks become accesible, the skua food supply increases. They also feed on the carcasses of dead hicks and take any weak and undernourished young. In a typical summer hese food sources are always present hrough the latter part of the season, nd late in some seasons the supply nay be superabundant when severe torms kill many chicks. Uneaten, nummified chicks on the ground sugest that this situation may occur.
The skua's food supply does not ppear to have a short period of peak bundance. Instead, it seems either to



Penguins nest on the ridgetops, *left,* to avoid depressions flooded by water.

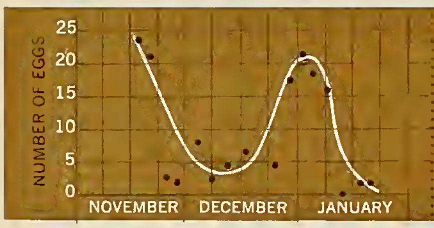


Skua and Adélie predator–prey studies were made on Antarctica's Cape Hallett.

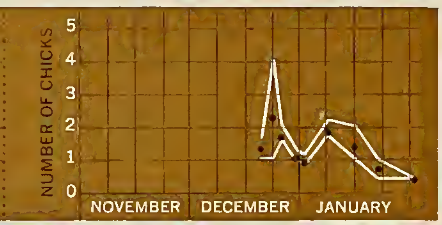


ARRIVING at breeding grounds earlier than skuas, Adélies lay their eggs first.

The penguins begin hatching in late November; skuas in mid-December.



NUMBERS of penguin eggs found in skua areas are plotted in four-day averages.



COUNT of penguin chick remains, at four skua nests, reaches two peaks.

increase or to remain relatively stable through the latter part of the season. If it did have a peak of abundance to which it adjusted, I would expect the population to show a high degree of synchrony in its breeding—that is, all pairs would breed at the same time. However, the 181 pairs of skuas that attempted to breed at Cape Hallett in 1960-61 began laying on November 10 and continued for 51 days. By the 13th day, only 54 per cent had begun laying.

In contrast, the Pomarine Jaeger (*Stercorarius pomarinus*), an Arctic-nesting relative of the skua, which I studied at Point Barrow, Alaska, in 1956, shows remarkable synchrony. The jaeger colony's egg-laying period spanned only 16 days; half of the eggs were laid in the first 6 days. The abundance of its food supply—the brown lemming (*Lemmus trimucronatus*)—declines in the latter part of the season, and the jaeger's synchronous breeding appears timed for maximum exploitation of available food. Another contrast with the jaeger is that the skua will readily renest if the first clutch of eggs is destroyed. One pair at Cape Hallett in 1960-61 produced three successive clutches. The Pomarine Jaeger, on the other hand, rarely renests, and the production of three clutches by one pair is unknown. If we assume that vertebrate breeding cycles are timed so that the young are raised when the food supply is optimal, then the protracted egg-laying period and the tendency to renest indicate that the skua does not usually have the problem of a decline in food supply toward the end of the season. The timing of its breeding schedule does indicate a dependence on the penguin breeding cycle, however. The skuas arrive in Antarctica shortly after the penguins, and lay their eggs slightly later (*see top graph, above*). Both of these events appear to be timed to insure that skua eggs hatch

WHEN chicks are half-grown, they begin huddling into crèches for protection.

ıfter penguin eggs, thus providing kuas with an augmented food supply vhen they begin feeding their chicks.

The breeding schedule of the Adéie Penguin is probably adjusted to ›roblems connected with its own food ›upply and the growth rate of chicks, ınd does not necessarily respond to kua predation. But several features of penguin behavior probably evolved, at least partly, as an adjustment to predation. For example, the habit of nesting in colonies in which individual territories are seldom more than a yard in diameter offers strong protection against skua depredations. Also, penguins sit closely on their eggs, protecting them from the skuas, from the extreme climate, and from the hasty feet of other penguins. Their high degree of attentiveness when brooding and feeding the young chicks serves similar functions. Association of half-grown young penguins in crèches, after the adults stop brooding them, is probably also a means of defense. Chicks that leave the crèche are often attacked by skuas, but if such chicks are able to get back to the crèche, they are usually safe from predation.

Penguins recognize skuas as "enemies," and adults show hostility by running or lunging at the skuas that walk near the edge of colonies or fly low overhead. Single adult penguins or groups that encounter a skua when away from the colony will frequently chase it, and if the skua is incubating, they will drive it from the nest and harass it as it tries to return. I did not see penguins destroy skua eggs in these encounters, but they seemed interested and peered intently at them. One wonders if perhaps a penguin behavioral mechanism insuring that they avoid other penguins' eggs causes them to avoid skua eggs as well.

THE crowds of skuas that gathered about any bait I put out to trap them indicate clearly that food was generally in short supply in the 1960-61 season. But another aspect of skua behavior suggests that the food supply is frequently critical when the chicks are growing. It has been noted by many observers that skuas seldom raise both chicks. Young skuas hatch a day or two apart, and the younger chick frequently disappears from the nest within three days of hatching. As I checked the skua nests daily, it soon became obvious that the younger chicks were being driven from the nest by their older siblings. Orphan young occasionally could be found on their parents' territories some distance from the nests, while the adults brooded and defended only the older chick. (Skua territories usually measure five to ten yards across.) Chicks would sometimes wander onto the territory of another pair and be adopted. In one instance I observed that a chick was

SKUA carries off penguin egg—perhaps one abandoned because of infertility.

adopted by a pair that had two eggs of its own. A few days later there was only the one chick in the nest. The adopted chick had apparently driven its foster siblings from the nest as they hatched. Loss of the second chick does not always occur, and thirteen pairs in 1960-61 raised both young. In instances in which more than one young was raised, the chicks sat side by side on the territory without hostility.

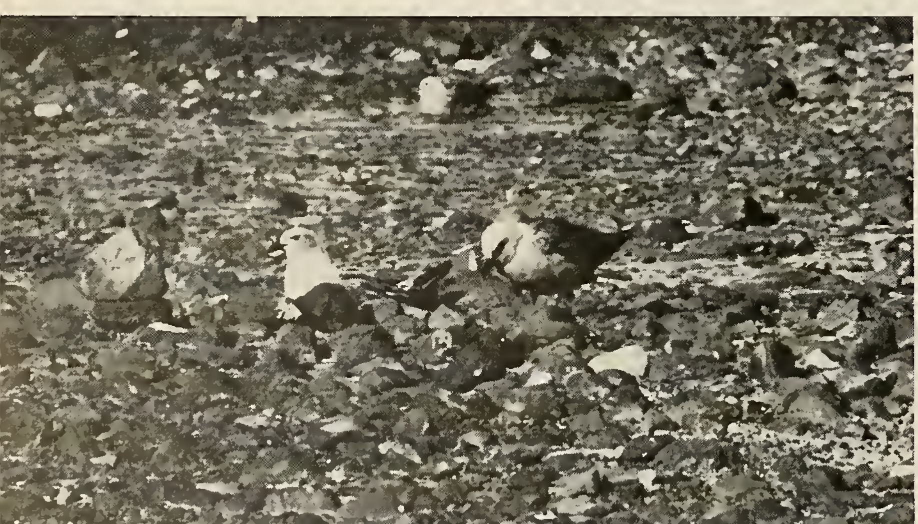
THE sibling hostility described above has also been noted by the New Zealand biologist E. C. Young. He ascribes the aggressive behavior of the chick toward its sibling to food shortage. I have some evidence, on the other hand, that it may be an inherited behavioral mechanism. Two skua eggs, already pipped, were brought into the field laboratory on December 14 and 16, 1960, respectively. The chicks were hatched separately, and when the younger chick was two days old and the other four days old, they were both put in a small box. As soon as they were together, the older one (named Modoc) reared back on its wobbly legs, raised its head, uttered a gutteral call, and lunged at the younger chick (named Gretchen, although autopsy later revealed it to be a male), which did not defend itself but attempted to flee. Three things should be noted: (1) neither chick had ever seen another skua before; (2) both chicks were well fed; and (3) only one of the chicks was aggressive.

We continued these experiments as the chicks grew older and found that the results were always the same. Modoc would rear up, utter his challenge call, and run at Gretchen as soon as the younger chick was in sight. Gretchen was never aggressive in turn, but always fled at the first sight of Modoc. When Modoc caught Gretchen, he pecked violently at his head, and from the first encounter it appeared that Gretchen eventually would have been killed or driven away if we had not separated them. Although both lived for five weeks, they could never be kept in the same cage.

The problem should be investigated further. If, as this observation suggests, aggression between chicks is an inherited mechanism that is not triggered by food shortages, the question arises as to why it is not manifested in all of the chicks. And, if some chicks show the response and some do not, as these observations suggest, and assuming that the mechanism contributes to the survival of the species, how is the balance maintained between those chicks that show the response and those that do not? Perhaps the food shortages are so irregular that the adaptation is not complete.

Let us now attempt to determine the number of penguin eggs and chicks that skuas actually take. When a skua takes an egg, it will either fly to a clear area in the penguin rookery or to its nesting territory to eat the contents. Penguin eggshells are conspicuous and we were able to record 1,889 in the penguin colony and skua territories in 1960-61. We stepped on each shell as it was counted so it would not be counted twice. Several people cooperated in the computation, and among us we traversed the entire penguin colony and visited the skua nests daily or every second day, so I believe the count was nearly complete.

While 2,000 eggs might seem a great amount, an estimated penguin population of 60,000 pairs would produce approximately 120,000 eggs. Thus, th



SKUAS generally take eggs to their own territories before eating. They nest near the penguins, on whom they are primarily dependent for survival.

WITH a characteristic display, skuas announce their claims to a territory.

lmost 2,000 eggs taken by skuas are ess than 2 per cent of the total. Even vith a doubled count, only about $3\frac{1}{2}$ er cent of the total number of eggs vould be taken by skuas.

There is another point to be conidered. Our records for the 120 skua ests visited regularly show, within a lay or two, when 629 of the penguin ggs were taken. Averaging the numer of eggs found at these nests at our-day intervals, we discovered heir distribution to be a bimodal urve (*see graph, page 46*). The first eak in the curve, in middle Novemer, may result from loss of eggs by hose penguins that were not motiated to protect them closely. The econd major predation peak came in ate December and early January—lthough penguin chicks began hatchng on December 5, and continued o hatch for the next ten days to two veeks. If we add up only the eggs ound on skua territories after Decemer 23, when most penguin chicks had atched, there were 323 eggs, or 51 er cent of the total eggs counted. Some penguin eggs do not hatch beause they are infertile, or because he embryo is killed by exposure to old or by damage to the egg. These are incubated, but if one or both of a lutch fails to hatch, they are eventually pushed from the nest. It is not uncommon to see penguins brooding a chick, with a rejected egg nearby. The above data suggest that half of the eggs taken by skuas are such rejected eggs—accounting for the second peak in the curve. Thus, in assessing the impact on the penguin colony of egg predation by skuas we must conclude that only about one per cent of the viable eggs are lost in this way.

THE number of penguin chicks taken by skuas is more difficult to measure. Direct counts are not possible. We can estimate the number, however, by using the information on food consumption that we obtained from raising young skuas in the laboratory, and by counting the penguin chick remains that we found near skua nests located in the penguin colony.

We fed the laboratory skuas on penguin chicks, and recorded the weight of the skuas and the weight of the food they consumed daily. At the same time, we confined thirteen young skuas at nine nests by erecting fences one foot high and ten feet in diameter around them. The adults could thus feed the chicks normally, and I weighed them daily or every other day to determine the growth rate of these wild young. One of the skuas raised in the laboratory had a weight curve that was the same as the mean curve of the thirteen fenced birds, and we used the amount of food eaten by this chick to estimate the number of young penguins taken by the skua population.

This chick lived for 35 days, at which time it had essentially ceased gaining weight and was apparently full-sized. Up to that time it had eaten 22.2 pounds of penguin. In the last eight days of its life, when it weighed between 2 and 2.5 pounds, the chick ate little more than a pound of food a day. Since the chick was almost full-grown at this time, we will assume that an adult skua eats only slightly more, or some 1.1 pounds per day.

Only about 75 per cent of a penguin chick is edible to a skua, so to deter-

FOOD SUPPLY is often low when skuas are hatching. When the parent broods only one chick, it is possible that the chick drove a sibling from the nest.

mine the actual weight of its prey we must assume that the weight of the food consumed represents 75 per cent of the total weight of the chicks killed or found dead. In the laboratory we fed the chicks only the edible penguin parts—the chick meat and stomach contents. In nature, therefore, the skua's prey actually weighs 25 per cent more, including both edible and inedible parts. The figures are, then, 30 pounds of prey killed per skua chick while it is growing, and some 1.4 pounds per day killed thereafter until it leaves the nesting ground. From these data we calculate that a pair of skuas that raises two chicks successfully will kill 386 pounds of penguin chicks, or an average of just over 5 pounds per day for 75 days.

Penguin chicks weigh about 3 ounces when hatched and about 8 pounds when grown. If we assume that the average weight of the chicks taken by skuas is 2.2 to 3.3 pounds, then a skua family with two young takes between 115 and 175 penguin chicks in the season, or between one and two chicks per day.

There is further evidence to confirm this estimate. I have already mentioned that a few pairs of skuas nested in open spaces within the penguin colony rather than in the main skua colony. These pairs defended a considerably larger territory than those in the skua colony, and could drag their prey to the nest site. I suspected that the penguin chick remains found near these nests were probably exclusively the prey of the skua pairs involved, and could be used to estimate the number eaten by any one pair. Four such nests yielded an average of 53 penguin chicks in approximately 45 days, or 1.3 chicks per day.

If all the 181 pairs of skuas nesting at Cape Hallett in 1960-61 were successful in raising two chicks, skuas would remove a maximum of 230 penguin chicks per day, or 17,250 per season, from the Adélie colony. Reproductive success is, in fact, usually much lower. In 1960-61 only 13 pairs raised both chicks successfully, while approximately 90 pairs raised one chick. Success for the skua population was thus between 30 and 35 per cent.

An estimate of 10,000 penguin chicks taken seems reasonable on the basis of the information we now have. This is 8 per cent of the potential of 120,000 penguin eggs. If we again assume that these figures are low and double them, predation would still account for only 16 per cent of penguin reproduction. Thus, predation impact on penguin eggs and chicks appears to be between 10 and 20 per cent.

At the heart of much debate over predation is the question of whether the predator takes prey at random or selectively, exerting a long-term effect on the prey population. Most students of predation believe that predators are selective and that the selective effect is beneficial, but proof of this is difficult to obtain.

In discussing the breeding of the Adélie Penguin I pointed out that the two eggs are laid two to three days apart, and when the second chick hatches, its sibling is already two or three days old. Frequently the second chick never overcomes this disadvantage. The older chick begs most of the food and grows faster, and the size discrepancy increases. When the penguin chicks gather into crèches, these starvelings can be picked out by their small size, their hunched postures, and by their out-of-proportion flippers and feet, which apparently grow at a near-normal rate to the detriment of the rest of the body. The exact proportion of dwarfed chicks in the skua prey is not known, but it is possible that underfed chicks that cannot defend themselves adequately make up a large part of the skua's prey. Many observers note that a chick that "stands up" to a skua will usually not be taken.

There are some other indications that the starvelings may be selected. The mean number of penguin chicks taken per day at the four skua nests studied in the penguin colony shows a peak early in the season, possibly indicating a greater number taken when the chicks are small, and a second peak in early January (*see graph, page 46*). This latter peak occurs at the time when the penguin young begin to form crèches, and I presume it reflects the access the skuas then have to chick carcasses and to starvelings that had formerly been protected by adults.

Dwarfed chicks do not account for all of the skua's prey, however. In the period when adult penguins are incubating or still brooding their chicks, the skua must count on taking the eggs or young of unwary adults. Sometimes two skuas will co-operate: one lures a penguin from its nest while the other rushes in and snatches the chick or egg. Some observers have shown that penguins nesting at the edge of colonies or in small groups apart from the main colony are most vulnerable to such attacks by skuas.

All the evidence we have discussed suggests that the skua population does not have a serious impact on the penguin population. Most of the eggs

Penguins gather in groups to protect themselves in a storm. An estimated 60,000 pairs breed on Cape Hallett.

r chicks taken are those that have een discarded or weakened because f a penguin food shortage, which, ven in the absence of the skua, would ause penguin mortality. There are, owever, certain situations in which redators hold down the level of prey -as with muskrats and minks—by pre- enting the prey species from occupy- ng some habitat because of predation. Sut that does not seem to apply here, xcept, possibly, for a few peripheral idges formerly occupied by penguins. 'hese peripheral groups are most sus- eptible to skua predation, and we can conclude either that the skuas prevent the permanent colonization of such mounds or that the penguin population undergoes long-term fluctuations for other reasons. If the former were true, I would expect that there would be continued attempts to colonize the peripheral mounds, but I witnessed no such attempts at Cape Hallett in 1960-61, and saw no evidence that there had been any recent colonization.

Almost nothing is known about the relationship of skuas and penguins in the winter months. The inability of skuas to prey successfully upon adult penguins in the breeding ground, however, suggests that their influence on the penguin population is restricted to the breeding season. And at that time, as we have seen, there seems to be no evidence that skuas significantly affect the numbers of penguins by their predation on discarded eggs and weak chicks. Instead, all the evidence points to the conclusion that skuas have a difficult time preying on penguins. Adélies have evolved effective behavioral means of thwarting skua predation, and by so doing severely limit the Antarctic skua population.

SKY REPORTER

Flight of Mariner II changes theories about planet Venus

By Thomas D. Nicholson

Venus changes from a gibbous phase to a narrow crescent.

A few nights before Christmas, on December 21, 1965, Venus reached greatest brilliancy as an evening object during its present cycle of configurations. Less than two weeks later, on January 3, 1966, the planet becomes stationary in right ascension and begins to approach the sun swiftly. By the middle of January, it will be difficult to see Venus at all in the evening sky, even though it will still be bright. On January 26, the planet passes through inferior conjunction, coming between earth and sun, and enters the morning sky. From mid-February through the balance of the winter and into the spring and summer, the planet will go through its configurations as a morning star, and will be seen coming up in the east before sunrise.

Venus is always a little disappointing as an evening star when it passes through its brightest evening phases in late autumn and early winter, as it did last year. Although the planet becomes just as bright as ever and may move as far east of the sun as ever, its position in relation to the sun keeps it low in the sunset sky and causes it to set relatively soon after the sun goes down. Observing conditions are even less favorable when Venus is, at the same time, in the part of its orbit south of the ecliptic—where the plane of the earth's orbit extends out into space. Until about mid-December last year, Venus was relatively unnoticed in the evening sky. After that, it came into more prominence in the early evening sky, but it had, by then, only about another month left before it began disappearing into the glow of the sun.

As an example of how the position of Venus affected its role as an evening star during fall and winter, 1965/66, consider how it appeared in November as compared to early January. On November 15, 1965, it was at greatest easterly elongation, 47 degrees to the east of the sun, and should then have been in its most favorable position in the evening sky. Actually, at sunset on that day, Venus was only about 20 degrees high in the southwestern sky, and it set less than three hours after sunset. On January 1, 1966, on the other hand, Venus is much closer to the sun—34 degrees to the east; on the evening of January 1, it is nearly 25 degrees high in the southwest at sunset, and it remains in the sky for approximately the same length of time as it did on the night of November 15. And, incidentally, it is also brighter.

This past decade has produced some important, and at the same time startling, information concerning Venus, primarily by radio studies and by radar, from observatories on earth and in space. Venus was not the first planet to be detected by radio techniques. That honor went to Jupiter, when, in 1955, two young radio astronomers, Drs. B. F. Burke and K. L. Franklin, working at the Carnegie Institution in Washington, D.C., accidentally discovered intense bursts of radio energy emitted from Jupiter. This set off a wave of interest among other astronomers, who began to search for evidence of radio emission from the other planets, and Venus, because it comes so close to earth, was a prime subject for investigation. As a result, Venus became the first planet to have its temperature measured by means of radio observations.

The radio energy from Venus is known as "thermal radiation." Every object with a temperature above absolute zero radiates some energy at all wavelengths in the electromagnetic spectrum, but the distribution of this thermal radiation across the spectrum depends on the temperature of the object. A hot object radiates more energy at all wavelengths than a cool object, and objects at higher temperatures radiate more of their energy at shorter wavelengths. Objects as hot as the sun, for example, radiate most of their thermal energy at the wavelengths of visible light, whereas objects as hot as the planets radiate most of their energy at wavelengths much longer than light, in the infrared and radio portions of the spectrum. It is possible, by suitable application of the laws of radiation, to determine the temperature of an object from observations of the energy it radiates, but care must be taken to measure only the radiating energy itself and not the energy that may only be reflected from some other source.

Most of the energy we receive from Venus is reflected sunlight, and so tells us nothing about the planet's temperature. The planet does radiate some light, but so little in relation to the reflected sunlight that it could not be measured. In the infrared and radio portions of the spectrum, which have wavelengths longer than light, solar energy falls off rapidly and is absorbed by the planet more completely, while the amount of energy radiated by the planet increases. Before the development of radio astronomy, optical astronomers had succeeded in measuring the infrared energy radiated by Venus. The results indicated a temperature of about —40 degrees F., undoubtedly the temperature at some level in the Venus atmosphere above the clouds where, as is the case on earth, it is considerably cooler than it would be at the surface of the planet. It was felt that the surface temperature should be much higher—about 212 degrees F., based on Venus' distance from the sun.

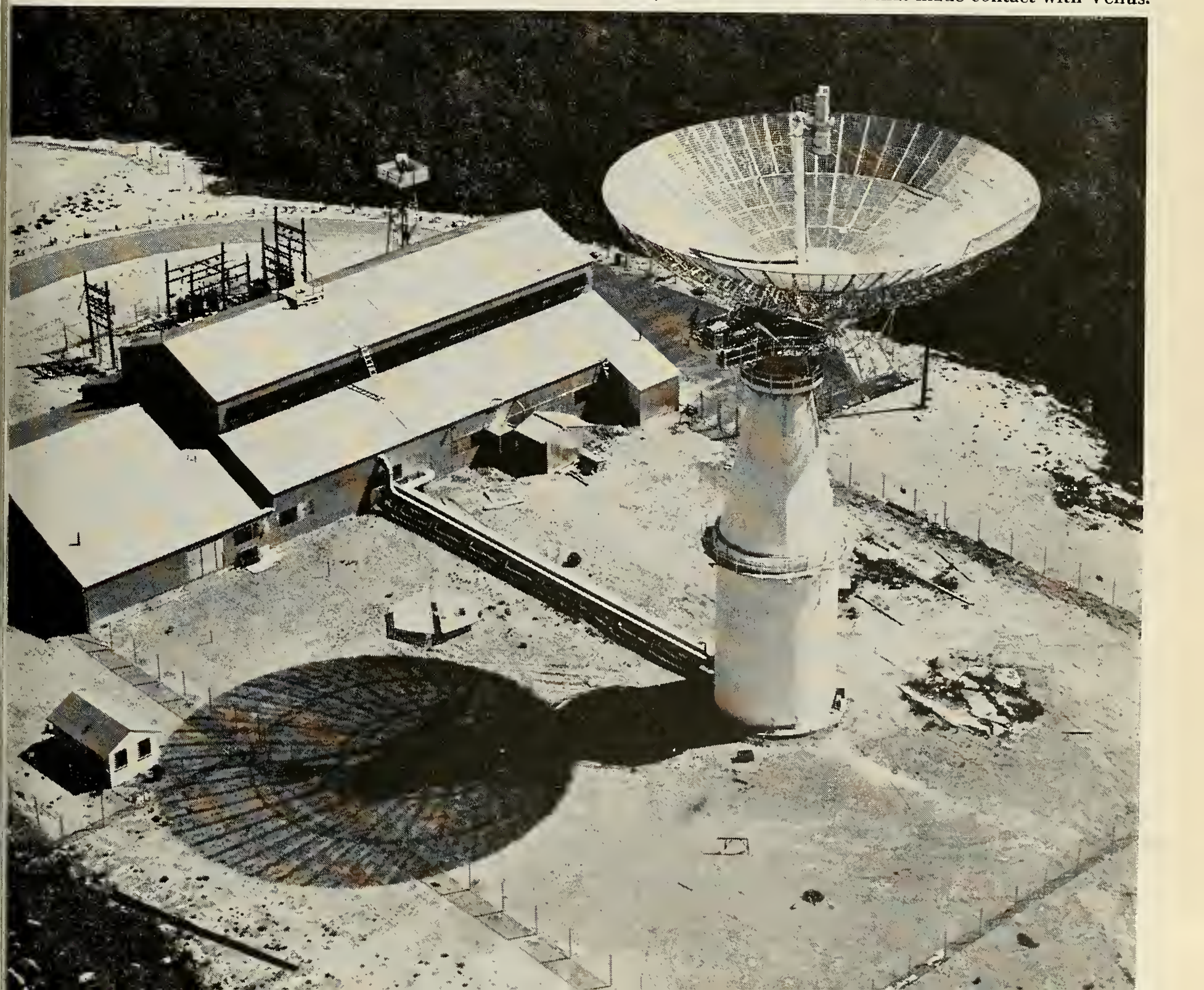
The use of radio telescopes to measure the temperature of the Venus surface was promising, since short-wave radio

:nergy, unlike infrared radiation, should penetrate the)lanet's cloudy atmosphere. When the Naval Research Laboratory astronomers measured the radio energy in 1956 it a wavelength of 3.15 centimeters, the result was sur)rising. It indicated that the temperature at or near Venus' surface, from which the radio energy was presumed to)riginate, was about 630 degrees F., far in excess of what iad been expected. Some astronomers were reluctant to iccept this seemingly improbable figure. They suggested hat the detected radio energy might not be thermal radiition, but might instead be produced by the Venus atmos)here, perhaps in an atmospheric region where charged)articles were emitting radio energy. This theory ran into serious difficulty when other astronomers observed the radio brightness of Venus over a range of wavelengths rom less than one centimeter to more than 40 centimeters, ind the data pointed to a high surface temperature.

Radio observations of Venus at wavelengths of less than)ne centimeter were made from the spacecraft Mariner II vhen it passed within 22,000 miles of the planet on Decem)er 14, 1962. Aside from measuring the intensity of the adiation—which confirmed the high temperatures observed it other frequencies from earth—the Mariner II experiment ought to determine how the intensity varied across the disk)f Venus. If the radiation were coming from an atmospheric layer—such as an ionosphere—surrounding Venus. the intensity of the energy observed should be highest at the edges of the planet, and signals should reach the Mariner antenna from a thick layer of atmosphere. If the radiation were coming from the surface of Venus, however, the strongest signals should come from the center of the planet, where the atmosphere along the antenna line was thinnest. The records showed that without doubt the radiation was brightest in the center of the planet, indicating that the measured radio energy could not originate in a high atmospheric layer, but rather came from the planet's surface.

Both infrared and radio observations have shed some light on the perplexing problem of Venus' rotation. Since we cannot see permanent markings on Venus, its rotation cannot be observed directly, nor can the effect of its rotation be observed in the spectrum of the planet (in the Doppler shift in the light from the edges of the planet as it rotates toward and away from the earth). Infrared observations show little difference between the temperature of the sunlit and dark portions of the planet, however, suggesting that it must rotate fast enough—perhaps once in several weeks or a month—to maintain a nearly constant temperature in the upper atmosphere. There is some evidence that

View of the Millstone Hill radar observatory at Westford, Mass., shows 84-foot antenna that made contact with Venus.



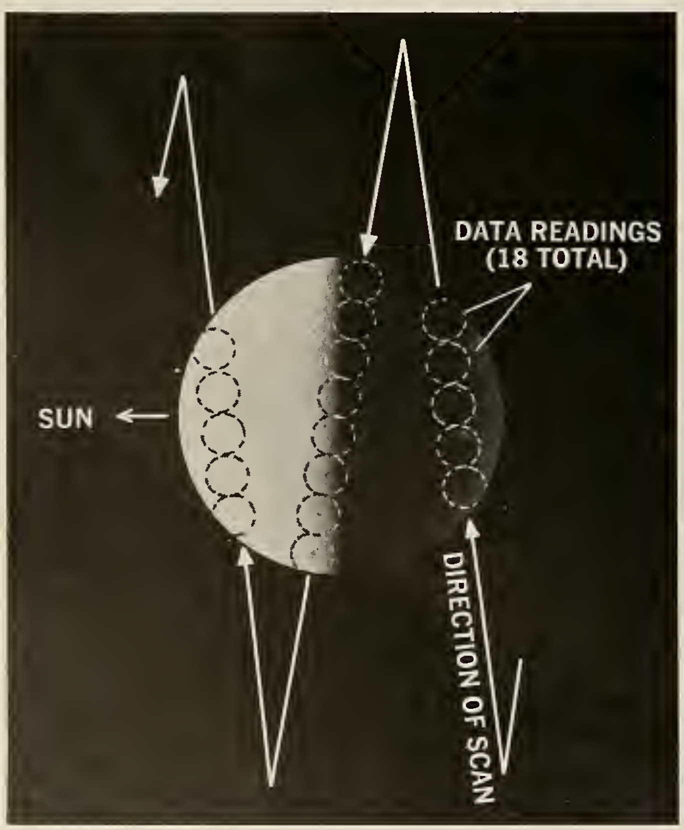
the radio temperature of the planet—presumably that of its surface—fluctuates about 250 degrees F., from the bright (daytime) to the dark (nighttime) hemisphere. This would be consistent, again, with a rotation period of several weeks to a month, but not with a long period of rotation; if rotation and revolution were synchronous, the nighttime side should cool much more than the temperature drop indicated. There must be some mechanism that transfers heat from the bright, sunlit side of Venus to the dark side, and the simplest mechanism to suggest is the rotation of the planet. Of course, the infrared and radio observations could be consistent with rotation periods over a wide range. The only thing such observations tell us clearly is that Venus does not keep one side toward the sun all the time. We know from other evidence (the absence of rotational Doppler shifts in the optical spectrum) that the planet cannot rotate as rapidly as the earth.

Radar observations from earth have given us additional evidence concerning the Venus rotation period. The earliest radar contact with the planet was achieved in 1958 by the Millstone Hill radar observatory, near Westford, Massachusetts, but the returning echoes were identified only after several months of carefully processing the records of the receiving antenna. In 1961, however, successful radar contact was made again at Millstone Hill, and also by two other American groups and by British and Russian teams. In these observations there was no doubt concerning the identification of the returning echoes, which were observed directly in the output from the receiving antennae. In the radar observations, as opposed to those made by radio, signals are beamed from earth in the direction of Venus, and the returning echoes are received after several minutes. The characteristics of the transmitted signal are known. Careful examination of the returned ech can provide information concerning the nature of the r flecting surface and how it may be moving. Radio wave for example, reflect differently from a smooth and a roug surface, and they are a more sensitive indicator of th Doppler shift produced by a planet's rotation than is ligh

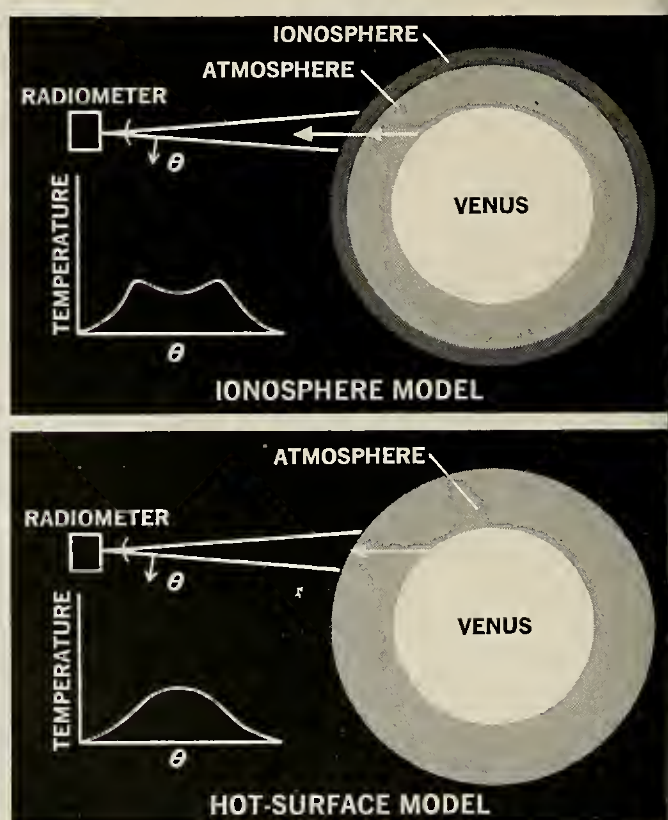
Thus far, radar observations indicate that Venus has surface that is not as rough, for example, as that of th moon. Different investigators have reached somewhat di ferent conclusions concerning the rotation period indicate by radar, but all agree that the planet rotates slowly, wit a period of a month or more. Some of the results show rotation period of 225 days—equal to the planet's perio of revolution—or longer, and it is now understood th Venus is actually turning slowly westward, rather tha eastward, as are the rest of the planets.

Perhaps the most valuable contribution to astronom from radar observations of Venus, however, is the acc racy with which they permit the distance to the planet be determined—calculated by the time elapsed betwee transmitted and returned signals. From this, in tur astronomers can compute the length of the astronomic unit (mean distance from earth to sun, a fundamental un in our scale of the universe) more accurately than by an other means. The best optical measures of the astronomic unit are correct to within about 10,500 miles, but the rada measurements are correct to within about 250 miles.

With respect to Venus, however, radio and radar obse vations have provided us with a good deal of interestin data, but these data have not always been consistent wi other things we know about the planet. We still cannot sa whether, beneath the shroud that hides its surface, Ven is a hot, dry, desert world or, instead, a steaming jungl

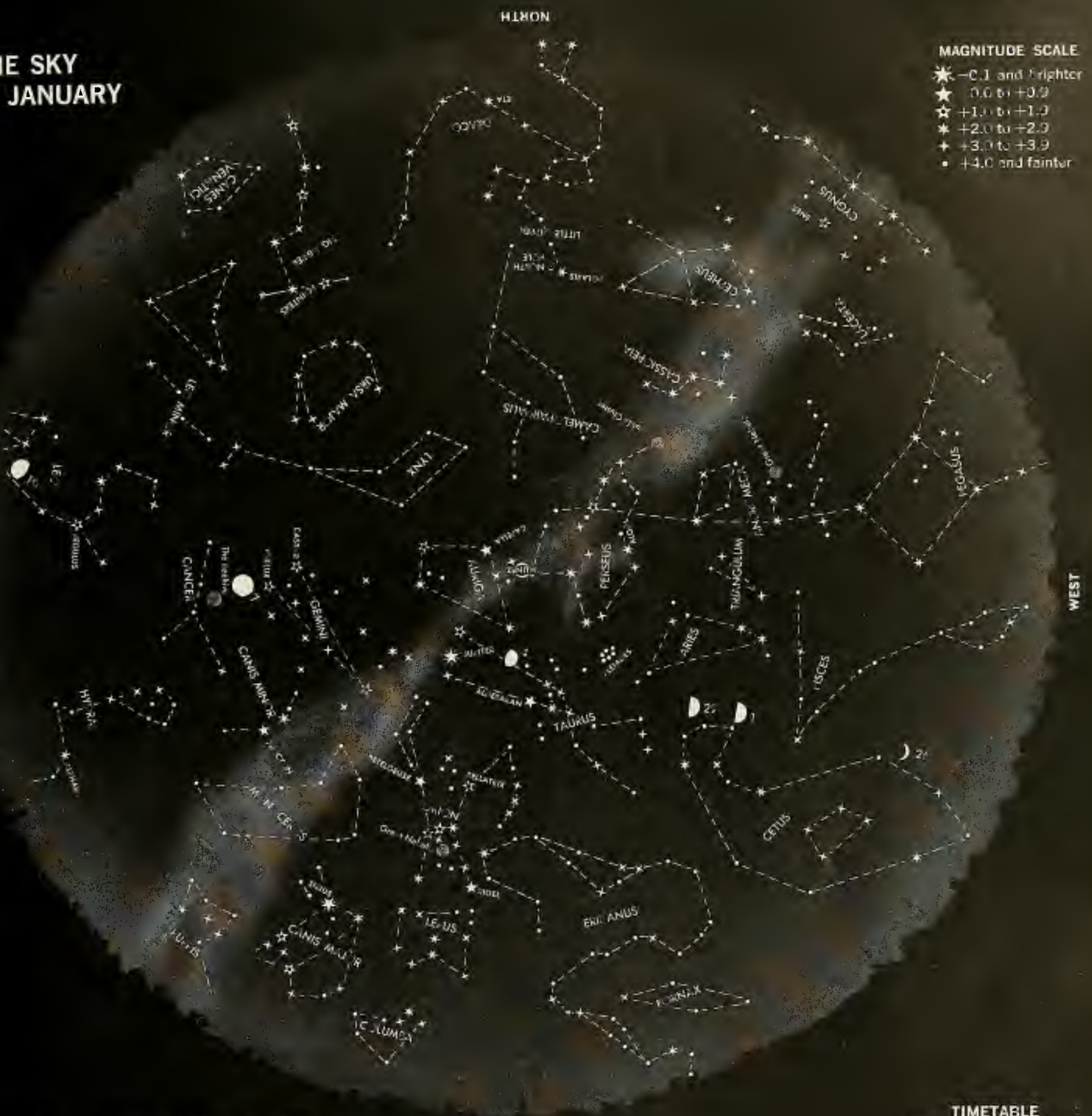


Scanner on Mariner II was moved up and down as the craft's motion, passing Venus, swept the antenna right to left.



Theories of Venus' temperatures are shown in atmosphe and surface models. Mariner II confirmed the latter theo

THE SKY IN JANUARY



Full Moon	January 7, 12:16 A.M., EST
Last Quarter	January 13, 3:00 P.M., EST
New Moon	January 21, 10:46 A.M., EST
First Quarter	January 29, 2:48 P.M., EST

TIMETABLE

January 1	10:30 P.M.
January 15	9:30 P.M.
January 31	8:30 P.M.

(Local Mean Time)

January 3: Today the earth is at perihelion (the point nearest the sun) in its orbit. The distance between earth and sun is about 91,345,000 miles.

Venus is stationary in right ascension and begins to move in a retrograde direction. Still a bright evening star (magnitude −4.2), it is now approaching the sun rapidly and will set progressively earlier each day.

January 5: Jupiter and the nearly full moon appear close to each other in the eastern sky after sunset. Conjunction of Jupiter and the moon occurs at about noon, EST. By 7:00 P.M. the moon and Jupiter will be above the horizon, Jupiter to the west (right and upward) of the moon.

January 7: Perhaps the last opportunity in some time to see Mars easily will occur tonight; the planet will be so close to Venus that the latter may be used as a guide. An hour and a half after sunset Mars, about magnitude +1.4, will appear as a reddish star in the southwest to the left of Venus.

January 24-25: Saturn is near the waxing crescent moon in the western sky during the early evening. On the 24th, Saturn is above and to the left of the crescent moon as the two draw closer each hour. Conjunction is at midnight, EST, on the 24th. On the 25th, the moon is to the left and above Saturn.

January 26: Venus passes between the earth and the sun at inferior conjunction and becomes a morning star, but will not be easily visible before dawn for several weeks.

All Month: Except for the first few days of the month, Mercury remains a poor morning star. It is too close to the sun to be found easily. Until midmonth, Venus gradually relinquishes her domination of the evening sky and in early February joins Mercury to become the morning star. Mars may be seen near Venus, but lower and much fainter. Saturn, about magnitude +1.2, appears nearby in the southwest after sunset and sets before midnight.

Between the bright stars of Gemini and Orion, Jupiter is the brightest object in the eastern sky during early evening this month. At magnitude −2.3, Jupiter outshines Sirius, the brightest of all the winter stars. It moves slowly into the western sky and remains visible throughout most of the night.


Great rapids of Columbia
Apr. 11. 1806.
HERBARIUM OF
ACADEMY OF NATURAL SCIENCES, PHILADELPHIA.
Berberis aquifolium Pursh.

The Lewis and Clark Expedition's Botanical Discoveries

Leaves of the Oregon grape, Berberis aquifolium, *at left, were gathered near Columbia River rapids in 1806.*

Century-old print depicts Lewis and Clark meeting with Indians. Their journey lasted more than two years.

They found many western plant species never before collected

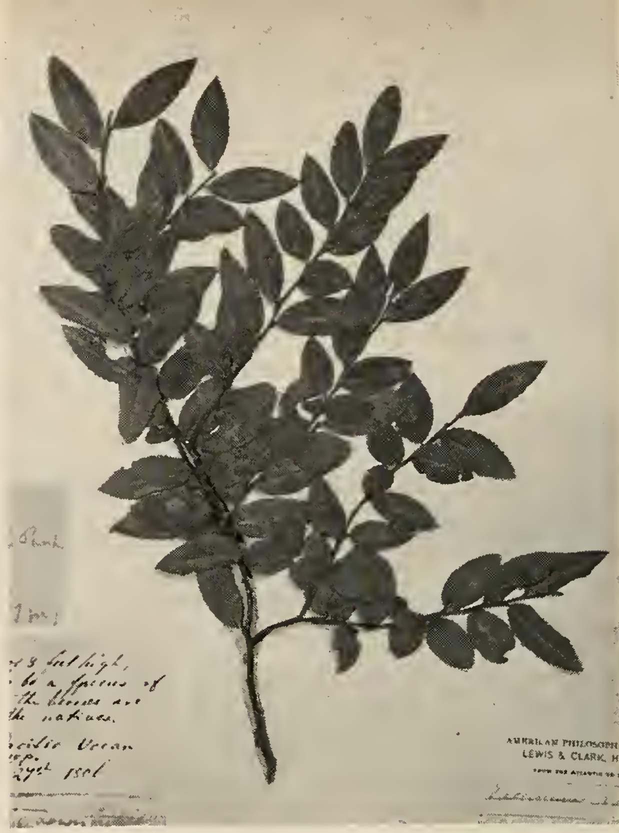
By R. D. BURROUGHS

-he botanical discoveries of Meri- wether Lewis and William Clark ave been given less attention than ny other phase of the explorers' ac- omplishments. Possibly this is be- ause plants are thought to be less ppealing and spectacular than ani- ıals, and also because the hardships nd adventures of these men make ıore exciting reading than do descrip- ve accounts of vegetation. However, homas Jefferson, who promoted and lanned the expedition, had more in ıind than finding a practicable route › the mouth of the Columbia River ıd enhancing the United States' claim › the Oregon Territory.

As soon as Congress had approved the enterprise in 1803, Captain Meriwether Lewis, Jefferson's private secretary, was appointed expedition leader. But to assure competent leadership in case Lewis was killed or incapacitated during the journey, Second Lieutenant William Clark, who had served with Lewis under General Anthony Wayne, was selected as coleader and was promised equal military rank. Although Clark had withdrawn from active duty in the Corps of Engineers, he accepted the appointment. The Army refused to grant him a captain's commission, but Lewis always referred to him as Captain Clark, and none of the men who served under them knew that they were not both captains. Clark, a skilled surveyor and cartographer, was responsible for surveying and mapping the course of the expedition. Lewis served as chief naturalist because he had spent a few months at the University of Pennsylvania studying geology, mineralogy, and botany. However, both Lewis and Clark were experienced wilderness travelers with a practical knowledge of the botany and zoology of the Atlantic states and the Ohio Valley.

In a letter of instructions, dated June 20, 1803, President Jefferson clearly defined Lewis' responsibilities and outlined the objectives of the expedition, which was to be called the Corps of Discovery. He emphasized

About the buffalo berry, Shepherdia argentea, *Lewis wrote: "it has much the flavor of the cranbury."*



Twig of an evergreen huckleberry, Vaccinium ovatum, *was collected near Fort Clatsop, January, 1806.*

the necessity of dealing peaceably with the Indians and keeping detailed, accurate records. He ordered Lewis and Clark to survey and map the course of their route to the headwaters of the Missouri, across the Continental Divide, thence to the mouth of the Columbia River; to note the soil, topography, and mineral resources of the country; to keep records of temperature, the proportion of rainy and clear days, the amount of precipitation in the form of rain and snow, prevailing winds, and length of the frost-free season; to study the ethnology of the Indian tribes encountered, including their locations, principal chiefs, populations, dress, manners, health, language, traditional enemies, economic status, and trade potential; and, finally, to study and collect as many animals and plants as possible, not wasting time on those species already known east of the Mississippi.

Few explorers have undertaken a larger task or achieved greater success in carrying it out. Their survey notes were meticulously recorded, and their maps of the areas explored were the best available for fifty years. Their notes on the customs and condition of the western Indians were voluminous, and their descriptions of the animals and plants they observed and collected were far more accurate than might have been expected, considering that neither was a professional or experienced naturalist.

Some of the plants that Lewis and Clark described in their diaries or mentioned having collected were damaged or lost for lack of adequate means of preserving and transporting them across the continent. Those collected on the outward journey, between Fort Mandan and the Pacific coast, were packaged and cached underground along with animal and bird skins and other objects that were too bulky to carry farther. But when the caches were opened on the return trip, practically all the specimens were found to have been ruined by moisture. Thus only those that had been shipped to the President from Fort Mandan and those collected either at Fort Clatsop, near Astoria, Oregon, or on the return journey were brought safely out of the wilderness. These consisted of about 200 pressed plants.

Jefferson, after examining the plants, entrusted the collection to the American Philosophical Society for study by the eminent Dr. Benjamin S. Barton of the University of Pennsylvania. The professor did not publish the results of his research, however, and the herbarium specimens were made available to Frederick Pursh, a European-born-and-educate botanist who was in Philadelphi working on the flora of North Amer ica. Pursh examined 155 of the speci mens and found that the majority wer entirely unknown to science. Amon them he classified four new genera an 123 new species, and his technical de scriptions appeared in his *Flora Amer icae Septentrionalis* in 1814.

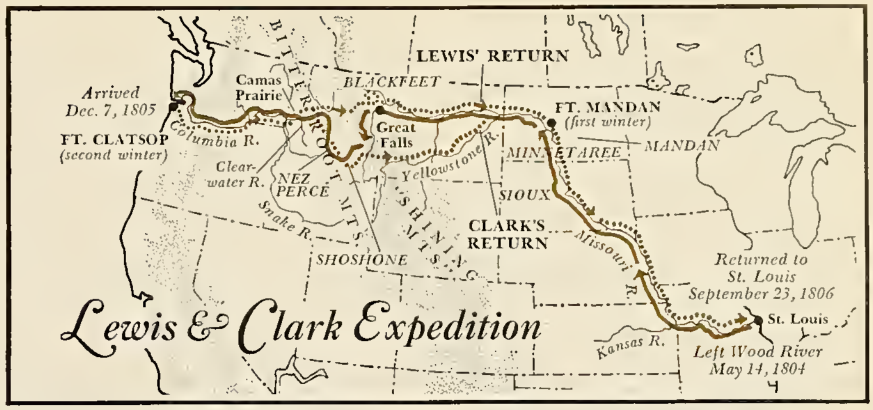
When Pursh returned to Europe i 1811, he took along many of the mos interesting specimens, presumably fo further study under the direction c Sir A. B. Lambert, vice-president c the Linnaean Society of London. Bu after completing his work, Pursh ne lected to send the specimens back t Philadelphia, and they became part c the collection of the Lambert Herba ium of the British Museum. Howeve more than thirty years later, in 184 they were purchased at public auctio by Edward Tuckerman, an America botanist, who presented them to th Academy of Natural Sciences of Phi adelphia in 1856.

The history of the collection durir the next forty-five years is obscur It seems that those purchased by Tuc erman remained at the Academy, ar those that had been left at the Amer can Philosophical Society were bu dled up, stored away, and forgotte They were not resurrected until 189

talk of blue flax, Linum lewisii, *is ne of the 188 preserved plants.*

hen the building occupied by the hilosophical Society was renovated. ortunately, at that time the botanist homas Meehan searched for the ewis and Clark collection among the dds and ends of supposedly worthless iaterials tucked away in old cabinets nd cubbyholes. He found it, among ome dusty bundles of pressed plants. ome of the specimens had been damged by insects, but most of them were fair condition. All but fifteen of the 55 plants examined by Pursh were ccounted for in this group, and could e positively identified because they ore labels in his handwriting.

After examining the plants himself, leehan had his classifications verified



Throughout expedition the explorers recorded the country's topography, animals, plants, minerals, and the locations and habits of Indians.

at the Gray Herbarium at Harvard, and then placed the specimens in the herbarium of the Academy of Natural Sciences. Thus the collection—a total of 188 specimens—was once again consolidated at the Academy, where it is now carefully preserved and is available for examination by qualified botanists. (The photographs on these pages are a selection of the plants.)

The plants in the existing group, as important as they are historically, do not actually represent the scope or diversity of the explorers' botanical observations. Jefferson had specifically requested that Lewis take note of the "vegetable productions" of the land, the dates on which various plants put forth their flowers, the quantity and distribution of vegetation, and the kinds of wild or cultivated plants that provided food for the Indians. Evidently Lewis made a conscientious attempt to record as much of such information as circumstances permitted. Considering the difficulties of travel and the problems of survival that the expedition surmounted almost daily, it is hard to imagine how they found time to write so many descriptions. One must read their diaries to gauge their true stature.

In popular accounts of the expedition, Sacajawea, the Shoshone squaw of a French Canadian interpreter and cook who accompanied them from Fort Mandan westward, is often credited with collecting certain roots in sufficient quantity to save the party from starvation; it is true that she did collect roots, including those of an umbelliferous plant the Indians called "cous" (*Lomatium cous*), when little else was available. In this connection Lewis wrote in his diary on May 21, 1806: "we would make the men collect these roots themselves but there are several species of hemlock which are so much like the cous that we are afraid they may poison themselves."

The truth is that most of the roots consumed by the expedition were purchased from the Indians. When, on the return journey, Lewis and Clark ran out of blue and white beads and other trade goods while encamped on the Clearwater River, Clark exchanged his medical services for such food items as horses, dogs, dried salmon, and roots. They were fully aware that any information obtained concerning the native plants eaten by the Indians would be important to subsequent travelers, and they devoted considerable space in their diaries to descriptions of such plants and how they were cooked or preserved.

The Sioux and Blackfeet Indians of the Dakotas and Montana were not ordinarily as dependent upon wild food plants as the Indians of the Columbia River Basin. Vast herds of bison and other game species fulfilled their basic needs for food and clothing. But they did supplement their diet with roots, seeds, and fruits. Lewis and Clark were particularly impressed with a leguminous plant called *pomme blanche* by the French Canadians in their party. Pursh subsequently classified the plant as *Psoralea esculenta.* On May 8, 1805, Lewis wrote a detailed description of this plant, including an account of how the Indians used its roots in cookery. In the fresh state the roots were either boiled with meat or roasted over hot coals. When dried in the sun or in smoke, they would keep perfectly for months or years; flour made from the dried roots was used to thicken stews and soups. Lewis closed his discussion by writing: "The white apple appears to me

to be a tasteless insipid food of itself, though I have no doubt but it is very healthy and moderately nutritious."

The Indians of the upper Missouri Valley made extensive use of sunflower seeds, first parched and then pounded. Sometimes the resultant flour was used in cooking gruel, but more often grease was added to make it the consistency of dough. Lewis said he ate heartily of this uncooked mixture and found it palatable.

In contrast to the Sioux and Blackfeet, the Mandan and Minnetaree Indians made little use of wild plants. They lived in permanent villages, some fifty miles above the present site of Bismarck, North Dakota, and cultivated extensive fields of maize, squashes, melons, and tobacco.

Lewis included a few ears of Indian corn and some tobacco seeds among the specimens and artifacts that were sent to President Jefferson from Fort Mandan in the spring of 1805. Pursh must have planted some of these seeds for, in his *Flora Americae Septentrionalis*, he says that the corn "ripens earlier and produces as excellent ears as any sort I know," and he claims that the tobacco, *Nicotiana quadrivalvis*, is excellent. Clark's appraisal of the Mandan tobacco was, however, somewhat less enthusiastic. He described it as "different than any I had seen before; it answers for smoking but not for chewing."

After passing over the Continental Divide, in September, 1805 Lewis and Clark found themselves in a land of scarcity. There were no buffalo west of the "Shining Mountains" (Lewis' name for the Rocky Mountains), and deer and antelope were scarce. Salmon had not yet started to run in the tributaries of the Columbia. While descending the western slopes of the Bitterroot Mountains, the men were reduced to eating horses, dogs, coyotes, owls, and crayfish. By the time they located a friendly band of Nez Percé on the banks of the Clearwater River, they were close to starvation. Then, of course, they ate too much of the dried fish and roots (probably *Lomatium cous* and *Carum gairdneri*) provided by the Indians, and became violently ill. This combination of food, which formed the staple diet of the Shoshones and Nez Percé, always induced dysentery among the explorers unless it was supplemented by substantial amounts of fresh meat. Possibly the somewhat putrid fish was more responsible for their trouble than the roots.

Among all the food plants used by these Indians, camass, *Camassia quamash*, was the most important and widely known. There was scarcely an explorer or pioneer who did not depend on it in case of emergency. On June 11, 1806, Lewis devoted several paragraphs of his diary to a detailed description of *Camassia*, which was then in bloom. Camass flowers are blue, and Lewis likened the camass prairies to lakes of blue water. He noted that camass grew only in open flats and glades; that it thrived in rich, moist soil; and that it grew most luxuriantly where the land remained from six to nine inches under water until late in June, when the plants neared maturity. In Lewis' words, the camass "seems devoted to its particular soil and situation, and you will seldom find it more than a few feet from the inundated soil, tho' within its limits it grows very closely, in short almost as much so as the bulbs will permit."

This was followed by a lengthy description of the Indian mode of steaming camass bulbs in earth-covered pits. Upon removal from the pit, the bulbs were either dried at once or made into loaves and steamed again. In either case they would keep indefinitely in the absence of moisture. Lewis wrote that camass was used in almost every dish the Indians prepared, but that it disagreed with him in every form.

On the other hand, the tubers of the common arrowhead, *Sagittaria latifolia*, which was as prominent in the diet of the Indians of the lower Columbia Valley as camass was in that of the Nez Percé and Shoshones, had no ill effects on the explorers. The arrowhead tuber, which the Indians called "wapato," grew "in great abundance in the marshey grounds of that butifull and fertile valley of the Columbia [*sic*]." Lewis and Clark exchanged beads and other cheap Indian trade goods for literally hundreds of bushels of these tubers during the winter of 1805/6, which they spent at Fort Clatsop. How many bushels of the roots were harvested annually by the Indians is unknown, but the total must have been very large. Lewis and Clark concluded that wapato (which is only one of the several spellings that appear in the *Journals*) was the principal article of traffic between tribes that owned the productive valley lands and those that lived near the sea coast. Harvesting wapato was squaws' work. Lewis was informed that the women would wade out in the shallow water, sometimes to their necks, and work the tubers loose with their feet. When freed, the tubers would bob to the surface where they could be collected and tossed into a canoe.

Lewis and Clark's botanical interests did not stop with the plants that yielded edible roots. They were also interested in range plants that provided forage for horses and wildlife. Concerning the western wheat grass *Agropyron smithii*, which is characteristic of the Columbia plains, Lewis noted that the high, semiarid plains of the Columbia River Basin supported a short grass that appeared to be as nutritious in its dry winter condition as during the summer months. Some of the horses that had wintered on thi

Among the new species they discovered was Artemisia cana, *a sagebrush.*

Most of the plants, now in Philadelphia, were described by Frederick Pursh.

Specimen from a big-leaf maple, Ac[er] macrophyllum, *measures 10 by 13 in*

ıss were "as fat as seals," in spite of ving been ridden hard by the Inıns. An authority on western flora, V. Piper, later pointed out that the nch grasses of the genus *Agropyron* noted for retaining their nourishnt after being cured on the ground, d that Lewis deserves credit for his en observation.

Likewise, Lewis was alert for plants ıt might have economic worth. He came interested in a variety of wild x (*Linum lewisii*) that grew in the ssouri Valley above the Great Falls. cause it resembled the cultivated riety, he thought it might "on experent yield good flax." He foresaw an vantage in developing this species cause it appeared to be a perennial ıt could be harvested without injury its roots. Whether any serious atnpt was ever made by later botanists or agronomists to domesticate *Linum lewisii* is not known, but it appears that if such attempts were made, they must have been unsuccessful.

This review would be far from complete if we neglected to include the shrubs and trees. The explorers made some notable discoveries in these categories. Frederick Pursh found among the botanical specimens several new species, including two kinds of sagebrush, *Artemisia cana* and *Artemisia dracunculoides;* the rabbit brush, *Gutierrezia serothrae;* the buffalo berry, *Shepherdia argentea;* buckbrush, *Ceanothus sanguineus;* the flowering currant, *Ribes sanguineum;* the purple sticky currant, *Ribes viscosissimum;* the buffalo or Missouri currant, *Ribes aureum;* the salmon berry, *Rubus spectabilis;* the Oregon grape, *Berberis aquifolium;* the mountain holly, *Berberis nervosa;* salal, *Gaultheria shallon;* and an evergreen huckleberry, *Vaccinium ovatum.* Some of these plants were described in technical detail and others in general terms. In Lewis' description of salal, a broad-leaved, evergreen shrub, he noted that the Indians gathered the fruits in large quantities, dried them, and pressed them into thick cakes for storage.

Being practical men as well as naturalists, Lewis and Clark took many notes on the timber resources of the West. They were careful to record the occurrence or the absence of trees suitable for lumber and fuel because such information would be of inestimable value to travelers and traders.

They were delighted to discover the Osage orange near the mouth of the

Kansas River, but they lost interest in it completely when they discovered that it was too tough to split and that its fruit was not edible. In contrast, they were impressed with the timber resources of the Rocky Mountains and the coastal plains west of the Cascades. During the winter at Fort Clatsop, they described the principal species of great conifers that grew in that vicinity. The Sitka spruce, *Picea sitchensis,* Lewis characterized as "a species which grows to immense size; very commonly 27 feet in girth six feet above the surface of the earth, and in several instances . . . as much as 36 feet in girth or over 12 feet in diameter, perfectly solid and entire. The timber is soft, white, and rives better than any other species which we have tried."

In similar detail he described the western hemlock, *Tsuga heterophylla;* the great white fir, *Abies grandis;* the western white pine, *Pinus monticola;* and the Douglas fir, *Pseudotsuga taxifolia.* Because the Douglas fir may be generally a more familiar species than most other western conifers, Lewis' description of the cones of this species should be of interest. He was first to call attention to the characteristic, thin, tridentate bracts that protrude from among the cone scales. This was twenty years before David Douglas visited the Oregon coast and succeeded in focusing the botanical world's attention on this magnificent tree that bears his name.

Among the broad-leaved trees that Lewis and Clark discovered and described, we find the Oregon maple, *Acer macrophyllum;* the Oregon crab apple, *Malus rivularis;* the red alder, *Alnus rubra;* the red hawthorn, *Crataegus columbiana;* the western dogwood, *Cornus nuttallii;* and the beautiful madrona, *Arbutus menziesii.*

Most technical descriptions of individual botanical species have been purposely omitted from this review because they would hold little interest for the average reader. It should be pointed out, however, that Lewis evidently had a basic knowledge of plant structure and knew many of the technical terms employed by botanists in describing flowers, leaves, stems, and roots. Moreover, in most instances he employed these technical terms with a fair degree of accuracy.

No plant was too large or too small to hold Lewis' attention if it was strange to him. Included among h[...] notable discoveries are some of t[...] most beautiful wildflowers that gr[...] in western America: Mariposa li[...] *Calochortus elegans;* death cama[...] *Zygadenus elegans;* glacier lily, *Er[...]thronium grandiflorum;* snow-on-th[...] mountain, *Euphorbia marginata;* sca[...]let mallow, *Sphaeralcea coccinea;* a[...] balsam root, *Balsamorhiza sagitta[...]*

It is to be regretted that Lewis a[...] Clark received so little scientific cre[...] for their pioneer work in botany. [...] the other hand, their diaries we[...] widely read in Europe and Ameri[...] following publication in 1814, and [...] can be assumed that the detailed a[...]counts of the variety, abundance, a[...] distribution of plant and animal li[...] did attract attention and were of co[...]siderable value to prospective weste[...] travelers for several years thereaft[...] Certainly, Frederick Pursh did not fo[...]get to honor the explorers when [...] named the plants they had collecte[...] Charles Francis Saunders, in *Weste[...] Wildflowers and Their Stories,* relat[...] the following anecdote:

It appears that Pursh, in examinin[...] the pressed specimens that had be[...] collected six years earlier, discover[...] that the fleshy root of one of them ha[...] retained a degree of succulence. I[...] placed it in a jar of water and p[...] it on the window sill. Within a fo[...]night it had put forth roots, leaves, an[...] ultimately, flowers.

Unfortunately, this delightful sto[...] departs from the facts. Pursh, himse[...] gives us a more plausible, alb[...] less spectacular, statement concernin[...] what actually happened. "This elega[...] plant would be a very desirable add[...]tion to the ornamental perennia[...] since, if once introduced, it would [...] easily kept and propagated, as t[...] following circumstance will clear[...] prove. The specimen with roots tak[...] out of the Herbarium of M. Lew[...] Esq. was planted by Mr. M'Mahon [...] Philadelphia and vegetated for mo[...] than one year; but some accident ha[...]pening to it, I had not the pleasure [...] seeing it in flower."

In any case, Pursh was so muc[...] impressed with this plant, the Mo[...]tana bitterroot, that he named it *Le[...]isia rediviva,* meaning Lewis' pla[...] that lives again. And, to insure equ[...] honor for William Clark, he name[...] one of the most arresting specimen[...] in the collection *Clarkia pulchell[...]* "beautiful" Clark's plant, called pin[...] fairies in some botanical reference[...]

About the Authors

Dr. Cyrus H. Gordon, a specialist on the origins of Western civilization, is Chairman of the Department of Mediterranean Studies at Brandeis University. Author of the article on the Phoenicians, he has discovered many of the linguistic and archeological links between early Greece and the Near East, and is an authority on the Ugaritic tablets that have revolutionized the study of Hebrew civilization. He has written more than three hundred books and articles, recently completing his largest technical work, *Ugaritic Textbook*, published by the Pontifical Biblical Institute of Rome.

J. Robert Smith, who wrote "Surinam Animal Rescue," is Chief Administrator of the International Society for the Protection of Animals (Western Hemisphere), and is a director of the Emergency Animal Relief Organization. Photographs for the article were taken by Patricia Caulfield, Executive Editor of *Modern Photography*.

A world traveler, C. Bruce Hunter has been photographing marine life along the coastal shores and on the coral reefs of the Atlantic and Pacific for many years. Author of "Myriad Colors in Coral," he is Supervisor of Program Development in the Education Department of The American Museum.

A lifelong interest in photography and four years of graduate research at the Institute of Atmospheric Physics at the University of Arizona provided the background for Richard E. Orville's article on lightning. He has an A.B. in physics from Princeton University, an M.A. in meteorology from the University of Arizona, and is now completing work for his Ph.D. The intense, localized thunderstorms of the Southwest provide an excellent source of lightning flashes for his ongoing spectral research on the physics of lightning.

In addition to his studies on the ecology and behavior of South Polar Skuas, Dr. W. J. Maher has also done comparative ecology studies on the Pomarine, Parasitic, and Long-tailed Jaegers in northern Alaska, and has studied the homeothermic growth and development of the Lapland Longspur and Snow Bunting. Author of "Predation's Impact on Penguins," Dr. Maher is Assistant Professor of Biology at the University of Saskatchewan in Canada.

R. D. Burroughs, author of "The Lewis and Clark Expedition's Botanical Discoveries," has recently retired from the Education Division of the Michigan Department of Conservation. He had worked for the Department since 1937, before which he taught biology at Willamette College in Salem, Oregon, Oklahoma City University, and Macalester College in St. Paul, Minnesota. He is currently teaching again at Willamette.

Naturalists' Notebook

Tree Ants Build a Nest

nsects link themselves together to fold large leaves into place

NTS of many species are noted for diverse and unusual traits. A case point is the nest-building activity the tree ants (*Oecophylla smaragna*) of southern Asia, New Guinea, nd northern Australia. While making ological studies on a Fulbright grant Australia, Dr. Daniel C. Wilhoft, ssistant Professor of Zoology at Rutrs, observed this species and took e accompanying photographs.

While the ants may utilize several ves of a living tree, the construction a nest often begins with a single f. The manipulation of a leaf such a scrub mahogany—measuring eight ches long and three inches wide—is a nsiderable feat for ants whose avere length is about three-eighths of an h. And once shaped, the leaf must secured in place.

To accomplish their objective, at st a hundred ants may swarm onto edges of a leaf. At different points, ants, by holding each other with ir jaws, form bridges between the f edges, the outer member of each ain grasping the opposing edge.

While the leaf is being held, other ts enter an already built nest and urn, each carrying a larva in its ws. The larva is held by the middle th its head free and pointing ford, so that it may briefly touch the ge of the leaf; then it is drawn away, ving behind a thin, sticky fiber of k exuded by the larva. This process epeated from side to side along the f edges until the silk is exhausted d a strong web holds the edges toher. It is then that adjacent leaves y be moved into position to reince the nest. They are also fastened h the silk. While nests vary in size, ne may be as large as a football.

Without a further supply of silk h which to spin its cocoon, a larva t has been used in nest building st undergo its subsequent development in a somewhat unprotected state. e nest provides security for it, however, as well as for the entire ant colony.

T at the extreme left, *opposite page*, grasped leaf of a shrub, as the other mbers of colony stream up the stalk.

CHAINS of ants, *above*, are formed as the insects hold each other with jaws and pull the edges of a leaf together.

NEST, *below*, was constructed from one leaf. It is secured with bands of silk, which are furnished by the ant larvae.

SCIENCE IN ACTION

Students in the Museum

By Bessie M. Hecht

SINCE its founding in 1869, The American Museum of Natural History has made many contributions to education. While that bald statement might not sound startling to old friends of the Museum, curiously, many of the contributions are known only to those who have participated in them. Of course, the formal instruction and extension services are well known. Other specific, equally important functions are the specialized guidance and direction of individual undergraduate students and doctoral candidates by staff scientists; the direct staff participation in the teaching programs of colleges and universities; the utilization of Museum collections in such programs; the support, maintenance, and continued enrichment of the libraries, which are among the largest and finest collections on natural history in the world; and the sponsorship of an extensive publication program. In addition, students come to the Museum to study the exhibits or to attend the special lecture courses. Still others—usually informally, on their own initiative—seek research opportunities.

Such opportunities have always been available, but six years ago a formal program was initiated in co-operation with the Special Projects in Science Education of the National Science Foundation. Its purpose was to enable college students to take part in the research activities of the Museum. In the past, student participation was often a matter of chance; this organized project permits the Museum staff to plan in advance to incorporate students into its research programs. Although a student may not be ready to carry out original investigations on his own, he can share in genuine research experience with competent scientists.

How the Program Operates

AT appropriate seasons, printed brochures that list research projects are sent to numerous colleges and universities throughout the country. When the students apply, they can request a specific project, but they must also include a transcript of their scholastic standing, two letters of reference, and a short essay describing their interests and goals. Applications are studied carefully by the Program Director and the investigators—all members of the Museum's scientific staff—and the better-qualified candidates are invited for interviews. Requirements are unquestio ably stiff—during the past six years the have been approximately 1,800 app cants, of whom fewer than 10 per ce have been selected to participate. The academic backgrounds ranged fro freshmen to seniors, with almost equiv lent numbers in each class.

The program is roughly divided in three sessions—the summer, the ac demic year, and the work programs. A schedules of starting and terminati dates are flexible, depending on the st dent's available time and the needs the research project to which he is a signed. During the summer program, t students work full time at the Museu for a minimum of ten weeks, or the project may take them to a field static or into the field itself—perhaps to t Southwest, to Mexico, or to the West I dies. In the academic year progra which runs from October to May, st dents from nearby colleges and univers ties work in the Museum for eight ten hours a week. The work progra accommodates students from colleg throughout the United States that ha co-operative or non-resident terms, su as Antioch or Bennington, or are on year-round schedule (as Harpur). Ear in the operation, it was decided that st dents would not be permitted to partic pate in more than two sessions, wheth or not they were contiguous or disparat Thus, it was possible for an individu to have two summers, two academic ye programs, or one academic year and o summer session.

At the end of each session, studen present their research results at sen inars specifically arranged for the these are attended by all the studen and investigators. In addition to t seminar presentation, each student su mits a written report on his work, fr quently in the form of a paper prepare for a scientific publication. Throug these various experiences, students a given the opportunity to explore a phases of scientific research, from in tiating a research problem to presenti results to their colleagues. A number students have coauthored papers wi the principal investigator.

For the summer and work progra sessions, the students receive a stipe of $600; for the academic year they r ceive $400, part of which, in the pa has been contributed through the Li coln Ellsworth Foundation.

A recent five-year survey covering the ɜriod through the summer of 1964 ıowed that 143 students (80 men and } women) had been selected from 61 ›lleges, situated in 18 states. It is of ›nsiderable interest that the majority : students came from the smaller colges. Of these former participants, 89 ıd received their bachelor's degrees. f these, 90 per cent of the men and 80 ɜr cent of the women were in 44 gradue or professional schools. More than a ıird have won honors such as Ful-right, National Science Foundation, ational Defense Education Act, Woodɔw Wilson, or Public Health fellowıips or scholarships. Two have re-ɜived their master's degrees, two have edical degrees. There has not been me enough for any to have earned a ›ctorate in philosophy. Some of the udents plan to continue their careers teaching at the college level. Others ıticipate working primarily in various pes of research organizations.

Research Activities

ONSIDERED on an individual basis, each research project may be comıred to research performed at universiɜs. However, when viewed as a com-›site, the research in the Museum is ıique in that it exposes students to ghly concentrated work. Few colleges ıve the extensive collections needed for udies in speciation and evolution, or ɜld stations that provide optimal faciliɜs for extensive projects. Programs ıder the direction of twenty-eight staff embers have been carried out in the ırious disciplines represented in the useum—animal behavior, anthropol-ɜy, astronomy, entomology, fossil and ving invertebrates, herpetology, ichyology, mammalogy, ornithology, verbrate paleontology, and vegetation udies. Students have engaged in studyg aspects of development of behavior fishes and mammals, the evolution of rds in the New Guinea-New Britain ea, brain function in fishes, evolution deep-sea corals, water metabolism in nd crabs, the morphological variation human craniums and skeletons, and ıalysis of cultural evolution. Other udents, in the field in Mexico, studied e significance of voice in the reproducɜe behavior of frogs and toads; still hers studied schooling behavior in hes at a marine biological laboratory.

Research at Field Stations

HE Museum operates four field stations: the Kalbfleisch Field Research ation at Huntington, Long Island, the ›uthwestern Research Station at Por-l, Arizona, the Lerner Marine Laboraɜy on Bimini, Bahamas, and the Archld Biological Station, Lake Placid, orida.

A few students have been engaged in research at the Southwestern Research Station on the biology of bees, the biology of army ants, embryonic adaptations of frogs and toads, and the vegetation of the Chiricahua Mountains. At the Lerner Marine Laboratory, studies were done on the production of underwater sound by fishes. Nearly a third of the participants have worked at the Kalbfleisch Field Research Station. This is a self-contained unit, whose oak woodland, evergreen plantings, weed fields, and ponds provide a variety of ecological communities. Nearly 200 species of vertebrates have been recorded there, and over 500 plant species are represented in the station's rapidly growing herbarium. Research projects now in progress include: (1) studies of the population dynamics of small mammals; (2) population ecology and breeding behavior of birds; (3) ecology of amphibians and reptiles; (4) population studies on cold-adapted fish; (5) investigation of the spectrum of radiofrequency radiation from Jupiter; (6) a survey of the flora and documentation of successional changes in the vegetation, studied through the controlled use of herbicides and burning. Many of these studies will be of a long-term nature, because protection is provided against vandalism and future disturbances that might arise through alterations in land use. A valuable feature of the station is the establishment of a system of 50-meter quadrats throughout the property, with lines that run true north-south and east-west. This grid system provides permanently marked reference points for recording observations and spots at which collections are made.

Benefits of the Program

A number of students apply from colleges in which their own research opportunities are limited to molecular biology, biochemistry, or microbiology. The Museum's program offers research in ecology, behavior, and systematics, both at the Museum and at field stations (to many, this opportunity is extremely important), and students discover that research in these areas is possible, rewarding, and modern. The program also demonstrates the interdisciplinary nature of the new biology and shows that modern experimental and observational techniques are applicable to the classical areas of biology. In addition, the program is broadening, as the students work closely with scientists other than their own professors. Not the least advantage is that during the summer, in particular, the stipend frees the student from financial burdens and allows him to devote his energies fully to his project.

To most students, the opportunity to observe and participate in continuing research projects of the Museum is an entirely new experience that helps to bridge the gap between the structured laboratory work at schools and research at a graduate level. The Museum staff, on the other hand, in its plans for such participation, helps to fulfill its public responsibility in the educational development and training of future scholars.

EDITOR'S NOTE: Information concerning current and future programs can be obtained by writing to Mrs. Bessie M. Hecht, Associate Program Director, Undergraduate Research Participation Program, The American Museum of Natural History, Central Park West at 79th Street, New York, N.Y. 10024.

This list details the photographer, artist, or other source of illustrations, by page.

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14-23—Robert J. Lee
24-29—Patricia Caulfield
30-33—C. Bruce Hunter except 32—AMNH
34-41—Richard E. Orville except 38—George S. Marcek; 40—AMNH after Orville
42-51—William J. Maher except map and diagrams, AMNH after Maher
52—Roland Rustad, Jr.
53—U.S. Air Force
54—left, NASA; right, AMNH after A. H. Barrett and E. Lilley
55—AMNH
56-61—Lee Boltin except 57—The Bettmann Archive; 59—map, AMNH
64-65—Daniel C. Wilhoft

Suggested Additional Reading

THE WORLD OF THE PHOENICIANS

THE PHOENICIANS. Donald Harden. Frederick A. Praeger, N.Y., 1962.

UGARIT AND MINOAN CRETE. Cyrus H. Gordon. W. W. Norton & Co., N.Y., 1966.

A TEXT-BOOK OF NORTH-SEMITIC INSCRIPTIONS. G. A. Cooke. Translated by Ernest F. Row. Clarendon Press, Oxford, 1903.

PHOENICIA AND WESTERN ASIA TO THE MACEDONIAN CONQUEST. Raymond Weill. G. G. Harrap and Co., London, 1940.

MYRIAD COLORS IN CORAL

THE GREAT BARRIER REEF AND ADJACENT ISLANDS. Keith Gillett and Frank McNeill. Coral Press, Sydney, 1959.

THE LOWER ANIMALS. Ralph Buchsbaum and Lorus J. Milne. Doubleday & Co., Inc., Garden City, 1962.

LIGHTNING THROUGH A LENS

PHYSICS OF LIGHTNING. D. J. Malan. The English Universities Press, Ltd., London, 1963.

THE FLIGHT OF THUNDERBOLTS. B. F. J. Schonland. Clarendon Press, Oxford, 1964.

THE LIGHTNING BOOK. Peter E. Viemeister. Doubleday & Co., Inc., Garden City, 1961.

THE THUNDERSTORM. Louis J. Battan. Signet Science Library Book, The New American Library of World Literature, Inc., N.Y., 1964.

PREDATION'S IMPACT ON PENGUINS

OCEANIC BIRDS OF SOUTH AMERICA. Robert Cushman Murphy. The American Museum of Natural History, N.Y., 1936.

THE PYGOSCELID PENGUINS. William J. L. Sladen. *Falkland Islands Dependencies Survey, Scientific Reports No. 17*, Colonial Office, London, 1958.

THE NATURAL REGULATION OF ANIMAL NUMBERS. David Lack. Clarendon Press, Oxford, 1954.

THE LEWIS AND CLARK EXPEDITION'S BOTANICAL DISCOVERIES

THE NATURAL HISTORY OF THE LEWIS AND CLARK EXPEDITION. R. D. Burroughs. Michigan State University Press, E. Lansing, 1961.

PLANTS OF THE LEWIS AND CLARK EXPEDITION ACROSS THE CONTINENT. T. Meehan. *Proceedings of the Academy of Natural Sciences of Philadelphia*, pages 12-49, 1898.

BOTANICAL CONTRIBUTIONS OF THE LEWIS AND CLARK EXPEDITION. V. E. Rudd. *Journal of the Washington Academy of Sciences*, Vol. 44, pages 351-356, 1954.

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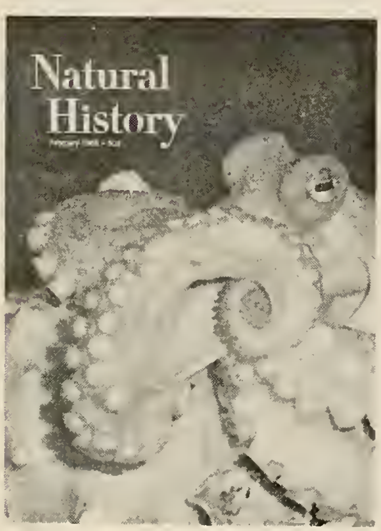

Natural History

Incorporating Nature Magazine

THE JOURNAL OF THE AMERICAN MUSEUM OF NATURAL HISTOR

Vol. LXXV — FEBRUARY 1966 — No.

ARTICLES

DEPARTMENTS

COVER: It will probably surprise most readers to find that the octopus c quickly be trained in a wide range of activities. The brain of the octopus relatively large for an invertebrate—that of an animal that weighs a little mo than a pound is made up of some two hundred million nerve cells that form mass about the size of a one-inch cube. Dr. Martin J. Wells, who discuss *Octopus vulgaris* Lamarck, starting on page 34, is obviously a great admi of his subjects, with which he has worked for several years. The cover pictu was taken by Dr. William Tavolga, Research Associate at The American Museu

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BOOKS IN REVIEW

Our dwindling heritage

By Stewart L. Udall

A Wilderness Bill of Rights, by William O. Douglas. *Little, Brown and Company, $5.95; 192 pp., illus.* The Wild Cascades: Forgotten Parkland, by Harvey Manning. *Sierra Club Books, $20.00: 128 pp., illus.*

The America of wild, remote, quiet places only miles beyond the city limits is about gone. In consequence, those few back-country areas that somehow have managed to escape the onslaught become more precious with each addition to our population.

One of our most sublime stretches of wild country, the North Cascades Mountains of the state of Washington, provides subject matter for two new books. Justice William O. Douglas alludes frequently to it in *A Wilderness Bill of Rights.* Harvey Manning devotes the whole of his new work. *The Wild Cascades: Forgotten Parkland*, to that portion of the mountain range running roughly from Mount Rainier National Park northward to the Canadian border.

The North Cascades are perhaps the least-visited expansive sector of the 48 contiguous states. Yet these 10,000 square miles contain some of our most superb scenic splendors: more than 500 glaciers; almost 300 mountain peaks reaching elevations over 7,000 feet; towering Douglas fir and ponderosa pine forests; and trout streams and lakes so pure that scores of cities and towns drink the water without filtration. Almost all of the area is in our national forest system.

Justice Douglas is a passionate partisan of the green and flowing world of the outdoors, a sworn enemy of the raiders and despoilers. *A Wilderness Bill of Rights* balances an earlier legal volume, *A Living Bill of Rights.* The new book ranges over the North Cascades and the rest of the nation, submitting case histories to prove the need for legislation to halt inroads into existing wilderness, to save some wild rivers, to preserve seashores, and to save habitat for endangered species of wildlife.

A Wilderness Bill of Rights uses as a premise Justice Douglas' belief that wilderness values, although not appealing to all Americans, are so basic to our national well-being that they must be honored by any free society that respects diversity. His bill of rights would protect the outdoor heritage of the passionate millions who find that "Wilderness helps us preserve our capacity for wonder—the power to feel, if not to see, the miracles of life, of beauty, and harmony around us."

Justice Douglas fires his shots sta cato. In *The Wild Cascades,* Harv Manning evokes mood and feeling wi word and picture. This is a work of a another in the Sierra Club's startling beautiful "Exhibit-Format Series." combines superbly reproduced phot graphs and skillful interplay of lin from Theodore Roethke's poems, wi Harvey Manning's text.

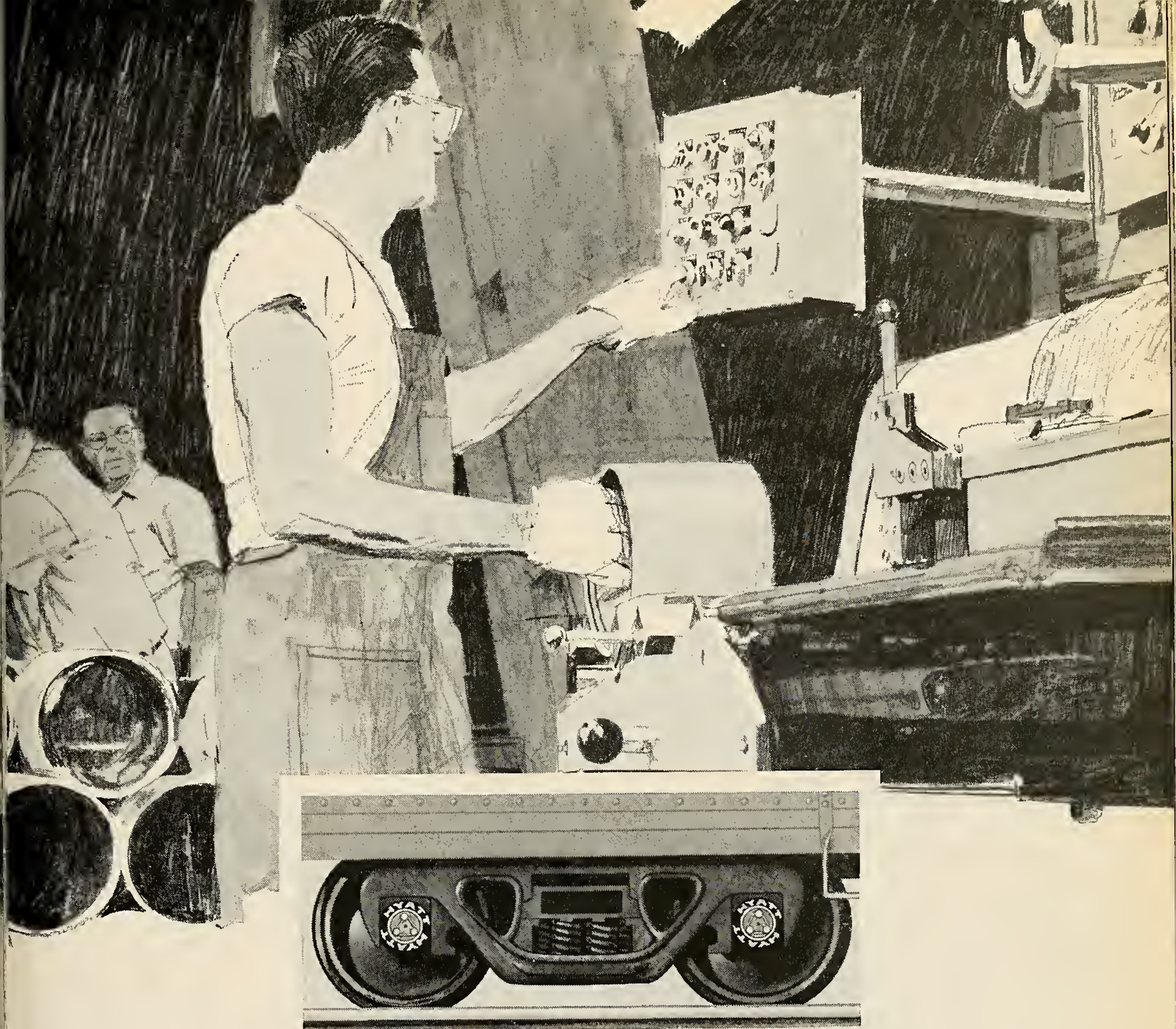
Manning writes as a quiet man wl has become perturbed. To him, tl North Cascades is a feeling, an expe ence. He approaches his mountai gently, nostrils flared for the first tellta aroma of peace and quiet and serenit He mulls over the low country, savors tl sogginess of camping in misty Casca rains, finds the high country meaty, e hilarating. And he objects strenuously development policies that he feels a destroying vital values.

The upshot is a proposal for establis ment of a new North Cascades Nation Park centered on the Glacier Peak a Eldorado Peaks area. Harvey Manni would flank his park with a Chelan N tional Recreation Area on the east, North Cascades Wilderness on the nort and an Alpine Lakes Wilderness a sho distance to the south.

Proposals for establishment of n tional parks in the North Cascades ha been many. The National Park Servi made one almost thirty years ago. Leg lation that might lead to a park has be introduced several times. The Depa ments of the Interior and Agriculture a now completing a detailed study of master conservation plan for the Nor Cascades. This study will put Manning proposals in sharp focus. It may be t late to produce a wise conservation pl for the entire region, but we must ma one last attempt.

A Justice, so we say, must be impa tial, but William O. Douglas is a braz advocate for a client—future generatio who will prize the wonders of outdo America. He speaks for forests and pr ries and foothills untouched by plows pesticides; for tundra and seashores u marred by the works of man; for u trammeled rivers "where it is safe kneel and drink deep."

Douglas' views are spacious. Most the time he has the big-sky country the West on his mind, but he also r cognizes the force of what Preside Johnson has called "the new conserv tion": the idea that miniature wilde



nesses a stone's throw from megalopolis—a Fire Island seashore, a Great Swamp of New Jersey—may be as important to the future as the preservation of Yellowstone Park.

An unsparing critic, Justice Douglas flays foresters who too loosely apply the concept of "multiple use," parkmen who condone overdevelopment of our national parks, range managers who wink at overfencing of the public domain, and wildlife managers who go along with ill-adapted efforts to achieve control of predatory animals.

He saves his sharpest shafts for those engineers who would build dams and roads in the wrong places. Some of his indictments may be overstated, but he is clearly convinced that much of our public work is carried on without sufficient regard for wilderness values.

Our conservationist-Justice issues a call for a "united front" against the despoilers. (He knows, too, that the fight will be won or lost on a thousand local battlegrounds.) He also suggests political action. His final solution is not for a national Wilderness Bill of Rights as such, but rather for the formation of an Office of Conservation, attached to the White House, to advise and counsel with the President.

This sounds like a pat solution, but those of us already "in the battle" wonder if the best team is not good field generals combined with Presidential aides sensitive to conservation values.

My own guess is that the President himself will always hold the key. We make progress when we have Presidents who really care about the land. We make little headway when the leaders of our nation lack interest or insight.

Justice Douglas' book has more meaning today than it would have had several years ago. It comes to a nation belatedly awakening to its waning heritage of natural resources. This year we heard for the first time a "Message on Natural Beauty" from a President of the United States, and many programs inspired by that Message now are under way. Significant new conservation legislation is on the books. Yet much remains to be done. The careful conservation insights of *A Wilderness Bill of Rights* will surely help guide us in the next steps.

Stewart L. Udall, as the Secretary of the Interior, has supervision over national parks. A lawyer by profession, Mr. Udall is author of the book "The Quiet Crisis."

Hydrospace, by Martin Caidin. *E. P. Dutton & Co., $5.95; 320 pp., illus.*

Although this is not a book on natural history in the usual sense, it will be of interest to everyone concerned with the natural world. Certainly, there is no frontier more excitin than the ocean environment, which th author calls hydrospace. Mr. Caidin whose bibliography includes an impres sive list of titles dealing with aviation aerospace, rockets, and the like, has em phasized the almost incredible array o devices and vehicles that are in use an are being planned for exploring and ex ploiting the oceans. Direct quotes fron scientists and statesmen concerning th importance and urgency of oceanic re search add dramatic impact an show the critical need for rapid progres in developing marine resources.

Much of the book stresses the militar aspects of the exploration of hydrospace and several chapters emphasize th comparison between American and Rus sian oceanography. Such comparison are severely hampered by security re strictions, but they should serve to aler the reader to the vital importance o supporting oceanographic research fo national defense reasons.

Two chapters entitled "The Harvest give an over-all survey of the current im portance and future economic possibil ties of the oceans. Minerals, food, an fresh water are there to be harvested, bu present-day technology is woefully in adequate, largely because the economi incentive is not yet strong enough t stimulate the necessary effort for fu realization of the ocean's potentialitie

Hydrospace is not a textbook of fact about oceanography. It is a dramati progress report on a rapidly develo ing frontier, and will be of interest t everyone concerned with the future humanity on this planet.

C. Lavett Smit
The American Museu

Ancient Society, by Lewis H. Morga *Harvard University Press, $7.95; 471 p*

A study of cultural evolution first pu lished in 1877, *Ancient Society* one of the classics of anthropology. has been reissued in a scholar's editic under the editorship of Leslie A. Whit A more suitable editor could not ha been selected. White has studied Mo gan's life and work for many years ar has also contributed to theories of cu tural evolution by expanding Morgan interpretation of human developmen

In a succinct and informative intr duction, White sketches the backgrour from which Morgan developed his theo of cultural evolution, acknowledges tl weaknesses of the theory, and at the san time points out Morgan's contributio to contemporary anthropology. Throug out the book, White provides enlighte ing footnotes regarding abstruse refe ences and areas of controversy. He al evaluates the contributions of Main Grote, and Morgan to the theory th primitive society is based on kinship ti

MAN AND NATURE LECTURES 1966

The second annual series of Man and Nature Lectures, sponsored by The American Museum of Natural History and the Natural History Press, will be delivered next month by Dr. George Wald, Professor of Biology at Harvard University.

'he lectures will be given in the Museum auditorium at 3:30 on the evenings listed below.

MARCH 7
The Prelude to Life
Despite the infinite variety of its manifestations, all life must arise under like circumstances and ust share a common constitution and common character.

MARCH 9
The Origin of Death
)eath, a late arrival in evolution, plays a positive role in the economy of life: men tend to misunderstand that role and their own relationship to it.

MARCH 14
The Sources of Human Nature
'he same forces of organic design that fashioned our anatomy ork upon our ways and institutions. 'o a degree we understand them; to a degree they present us with problems.

MARCH 16
The Human Enterprise
The time has come to reappraise human goals and aspirations the light of our present position and our view of man's place in nature.

Museum members may obtain invitations to these lectures by writing

Miss Maureen Mahon,
The Natural History Press,
The American Museum of Natural History,
Central Park West at 79th Street,
New York, N.Y. 10024

and modern society on property and territory—a functional hypothesis now popular in studies of social organization.

Morgan's scheme of cultural evolution consists of three stages: savagery, barbarism, and civilization. This scheme is based on differences in the systems of kinship terminology from various societies he had described earlier in *Systems of Consanguinity and Affinity* (1871). He believes these differences in terminology are due to varying forms of marriage and family structure, and that the kinship systems, and their associated forms of marriage and the family, represent different stages in the history of cultural evolution. According to this scheme, from most ancient times to modern civilization, forms of marriage change from promiscuity to monogamy. In addition, Morgan uses technological and other criteria—most significantly, the bow and arrow, iron, and pottery—as markers of the various evolutionary stages. Using these criteria, Morgan then ranks the cultures of the world in an evolutionary sequence.

This reconstruction of ancient society now has been found to be invalid. We know today that the family did not evolve in this way, and we recognize that the differences in kinship systems are an index to role behavior and attitudes toward relatives, rather than a reflection of the stages of family development.

However, this reissue of an old classic provides an excellent sourcebook for those interested in cultural evolution, social organization, and the history of anthropological theory.

Ruth S. Freed
New York University

A Continent for Science, by Richard S. Lewis. *The Viking Press, $7.95; 300 pp., illus.*

Antarctica is the last of the continents to be occupied by man. It has been only seventy years since the first man set foot on its mainland, and only ten years since men began to live there continuously. In this brief span it has proved so valuable as a scientific laboratory that, barring a catastrophe, present occupation will surely be permanent.

There is a need for a concise history of Antarctica. That need is only partly filled by this attractive book. The author is a newspaper reporter who has visited Antarctica twice and who has read a number of scientific papers and magazine articles about the area. He presents many facts, but they are often imperfectly digested.

The most successful part of the book is the history of the continent from the time its existence was first conjectured by the Greeks to the beginning of its occupation in 1955. There are some excellent photographs by Herbert G. Pon-

ting of the Scott expedition in 1911-12, but in the text some of the most interesting details of the story are omitted. For example, in describing the race between Scott and Amundsen to reach the South Pole, the author gives no explanation of the comparatively easy victory of the Norwegians and the fatal failure of the British. (The difference probably lay not just in the Norwegians' superior mastery of logistics but in their willingness to kill and eat their surplus dogs as their other supplies were used up.)

A once-over-lightly treatment is applied to the vast scientific work of the last decade in the fields of glaciology, geology, meteorology, biology, and upper atmosphere studies. The maps do not help; they are poster-like and devoid of detail. The modern photographs have been drawn primarily from the publicity files of the U.S. Navy. Many of them are excellent, but their connection with the text is tenuous.

The last chapter deals with the effects of the Antarctic environment on man, and it demonstrates the necessity for experience and judgment in evaluating data. In the United States Antarctic program, such supporting functions as transport, communications, and supply are performed by the Navy, and the environment at U.S. stations is more naval than polar. Men can easily spend the entire winter in one of the Antarctic stations without ever going outside. They eat better-than-average mess hall food, attend daily movies, and listen to recordings. Thus, it is neither surprising nor significant that "there is no evidence of physical changes that would indicate a polar adaptation in wintering-over personnel."

Although the author sometimes fails to weigh his facts, the facts are there, the photographs convey the atmosphere of the place, and in the absence of a more authoritative book, this one must be acknowledged as the best non-technical introduction to Antarctica's past and present.

DAVID LINTON
Polar Photographer-Writer

PORTRAIT OF A DESERT, by Guy Mountfort. *Houghton Mifflin Co., $10.00; 192 pp., illus.*

SCHOLARS tend to take a rather dim view of "popularly" written accounts of scientific research projects. This is most decidedly the case with those written about brief trips to the Near East, where enthusiasm often beclouds facts. Yet I must be effusive in praise of Mr. Mountfort's most recent volume—and of its solid scientific va[lue] for the general reader.

This relatively short book repres[ents] another in a series of word "portra[its]" that Mountfort has published about [the] natural sciences. It is a popular repo[rt of] the results of a short, but most intens[ive] twelve-man survey of the desert sec[tion] of the Hashemite Kingdom of Jor[dan]. The mission of the expedition, which [was] organized by Mountfort, was the sc[ien]tific investigation of the present [eco]logical situation of the area, in prep[ara]tion for broader studies proposed [by] the International Biological Programme. Not only was the basic purpose of [the] expedition achieved; its ancillary [find]ings are of utmost importance, as [w]ell.

The group was composed of [w]ell-equipped specialists representing [zoo]logical science, ecology, conservat[ion], ornithology, and history, and outst[and]ing photographic personnel—all o[f] whose individual skills are ably in[ter]preted by Mountfort's writing talent [and] technical knowledge. The volume pr[oves] once again the values to be gained f[rom] such interdisciplinary approaches in [sci]entific studies. The author employ[s a] personal approach to his subject ma[tter] which gives the necessary contin[uity] through the itinerary and schedule o[f the] mission. Thus the reader is able to [par]ticipate both in the gathering of the [data] and in the actual life of the exped[ition] as it worked in the field. The desc[rip]tions border upon the dramatic, e[spe]cially in regard to bedouin life [and] customs, but also in terms of the w[ild] life of the desert—its flora, its fauna, [and] the awesome aura that pervades [it].

This same dramatic element is car[ried] into the descriptions of the archeolo[gic]al and historical sites visited in the co[urse] of the work. It is only here that I [must] interject a slightly negative note. [The] historical and archeological informa[tion] supplied, here and there, is somet[imes] uncritical. For example, the identi[fica]tion of the Nabataeans with the Neba[ioth] of Gen. 25:13 is completely unten[able]; the rock-cut "temples" of Petra ar[e] tombs, Sir Julian Huxley was *not* [the] first to publish photographs of Pet[ra in] color, and the "Nabataean" po[t] sketched on page 122 includes a [late] Byzantine lamp. However, even a [spe]cialist in Nabataean studies will for[give] the author a great deal in return fo[r his] word picture of Petra!

Sympathy also colors the author's [feel]ing for the modern social and poli[tical] life of Jordan, illustrated by the int[erest] and activity of King Hussein's go[vern]ment in the land, its heritage, and [the] need for its conservation. Sociolo[gical] problems are related to ecological [ones] and an approach is made, via scien[tific] ecological analyses, for their solu[tion].

At the same time that this book [is]

continued on pa[ge]

Locomotion Without Limbs

Diverse mechanisms propel snakes on land

By Carl Gans

Snakes have traditionally represented objects of mystery to man. Their poison and, equally, the confusing "legless" way in which they move suggested that they were possessed of supernatural powers. Until fairly recently, naturalists used the name snake for any legless reptile, including amphisbaenids and the various limbless lizards. Such a classification is still popular among non-specialists and country people.

The diverse mechanisms by which such limbless animals move remain subject to argument and discussion. Only now have quantitative studies begun, and some of the points of contention been clarified. As might be expected, various locomotor patterns are used by the approximately four thousand limbless species.

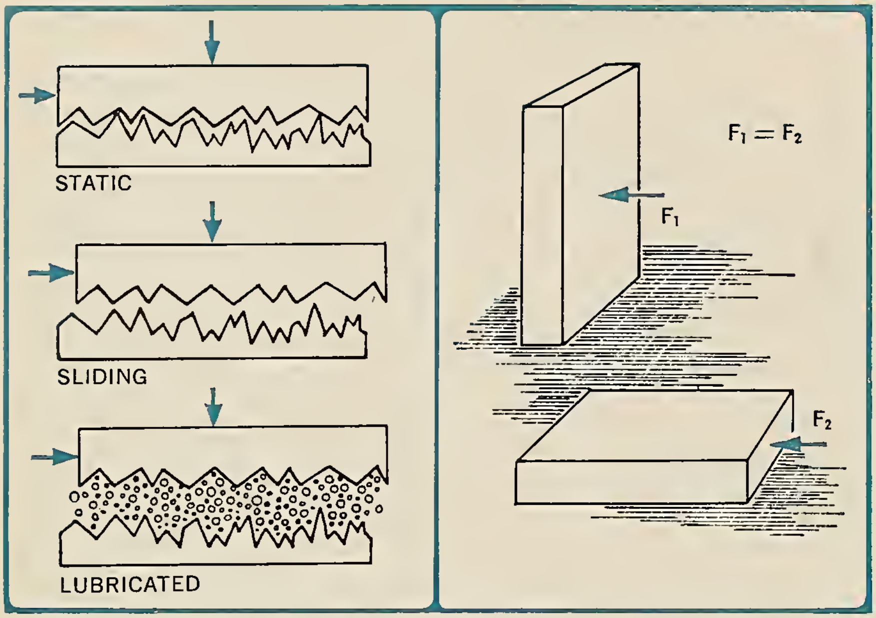
Many questions may be asked about these patterns. The obvious ones are: What are the mechanisms by which limbless vertebrates move? Is there a single underlying principle, or does each group move by a distinct method? What are the relative advantages and disadvantages of the methods? For what condition is each adapted? Is there a definite sequence by which one movement may be changed into another? A last question may then take us back to the basic problem: Why and how did these animals become limbless in the first place?

At least the first of these questions belongs in a research area known as functional morphology, a field that deals generally with the mechanisms of external and internal animal movements. It usefully combines aspects of anatomy and physiology with concepts from some areas of mechanical engineering. It is thus necessary to review certain physical principles to understand limbless locomotion.

Friction will be shown to be the key to an understanding of the changes observed, so we must begin with Newton's first law of motion, which states that a body at rest will remain at rest and a body in motion will remain in motion at a constant speed in a straight line, unless acted upon by an external force. An ice skater uses the practical application of Newton's law. He digs in the tips of his skates and pushes himself off to start, and tilts his skates when turning so that their sharp edges let him exert a sideways force that keeps him from slipping. Yet a speeding skater will slow down, even on smooth ice, unless he keeps pushing. The slowing effect is produced by the pressure of the air against the skater's body and the slight rubbing of the skates against the ice. Both involve aspects of friction, which may be defined as an interaction between two bodies moving past each other—an interaction that produces a force parallel to, but opposed to, the direction of motion. The application of the skate's tip or edges to the ice may then be thought of as a device for increasing the normally low friction between the skate and the ice. In the same way, an animal must exert a force against the substratum either to start moving or to accelerate. Similar forces, but in different directions, must be exerted to decelerate and to change the direction of motion.

Long ago, it was observed that for ordinary conditions the frictional force is generally proportional to the force pressing the two surfaces together. This is why it is easier to slide an empty trunk across a floor than a full one. The amount of frictional

Python supported by looped tail and braced against a tree symbolizes this animal's muscle strength and control.



THREE types of friction are at left. Force needed to slide blocks, right, over surface is constant, regardless of the areas of the contacting surfaces.

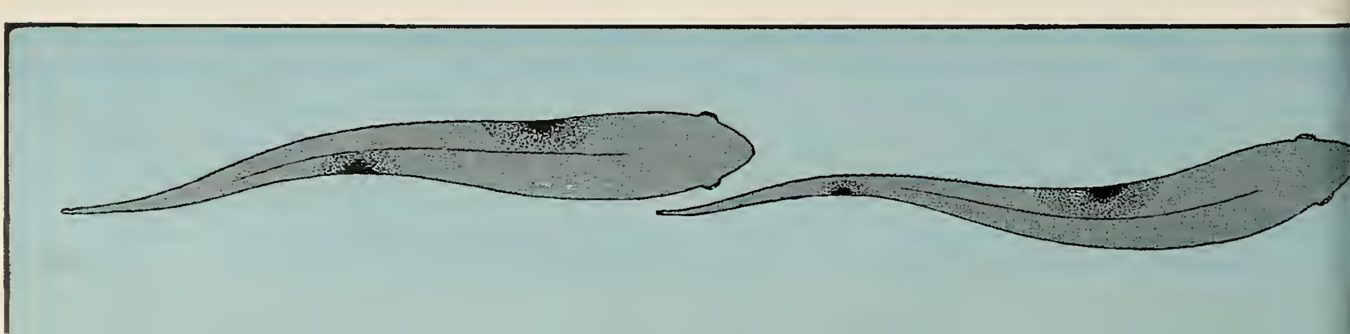
force is also a function of the texture of the surface. After all, it is easier to slide one's finger across a smooth table top than across a cinder block. Combining these terms we may state that the frictional force is: $F = k\ F_p$, in which F_p is the force pressing the surfaces together and k the coefficient of friction reflecting the texture of the surfaces and similar aspects. The frictional force may then be increased either by increasing the force holding the surfaces together or by increasing the coefficient of friction. This is why one must grip harder to hold a full glass than an empty one, and why more holding force is needed to lift a smooth ceramic object between two fingers than to lift one that is unglazed and rough-textured.

In considering the above equation, it is interesting to note that it does not contain a term for the area in contact. Frictional force is independent of the size of the surfaces. It is theoretically unimportant whether a uniform slab is pushed across a table while resting on its end, its narrow side, or its wide side *(drawing, above)*.

Factors other than surface composition and texture also affect the coefficient of friction. Engineers thus talk of static, sliding, and rolling friction. The first two of these may again be visualized on the basis of a simple model in which the two surfaces are exceedingly rough, populated, as it were, with peaks and valleys. When two such surfaces are pressed together, the peaks and valleys interdigitate, that is, the peaks of one drop into the valleys of the other. This poses a problem when force is exerted to slide the surfaces past each other. Work must be done to separate the surfaces before they are free to move in parallel. The peaks act as inclined planes during this movement, which is partly directed against the force pressing the surfaces together. This explains the proportionality. Once the surfaces are moving, they remain in limited peak-to-peak contact if the velocity is sufficient to keep the peaks from slipping into the valleys. The force that must be exerted for separation is generally greater than that needed to maintain motion; thus, the coefficie of static friction is generally se eral times that of sliding frictio The term static friction refers to th force that is potentially required initiate slippage. Such a force nee exist only at the moment that motic starts (in contrast to the force of sli ing friction, which must act contin ously to let motion continue). Tl force of static friction defines a regic of lesser forces, no one of which wou allow movement to take place.

The third and special case involv the so-called rolling friction. When wheel rolls over the ground, there wi ideally, be no relative motion betwee wheel and ground at their conta point. The wheel may thus be co ceived as an infinite number of litt feet placed one in front of the othe and replacing each other in stationa contact with the ground, although tl center of the whole unit steadily a vances. (A bulldozer tread in actic suggests a deformed wheel in slc motion. In such a system there is act ally no friction between wheel ai ground as long as the wheel is turni freely.) Only when the wheel begi to move so fast (or slow) that its low edge slips on the ground is there sor approach to sliding friction. Y whenever the wheel is kept from tur ing, the contact zone between the low edge and the ground yields the fi static or sliding friction. This explai the drastic results when a railro coach bearing freezes.

Thus far, the discussion has de with contact between two solid objec Frictional coefficients will, howev be reduced still further by the intr duction of an intermediate layer, so-called lubricant, between the t surfaces. Such a layer may consist numerous, relatively small, solid pa ticles or of various liquids and gas Such lubricants must coat the surfac and keep them apart so that their hi points cannot touch each other. T slippage then occurs entirely with the fluid, and the observed friction i function only of its viscosity, or of t

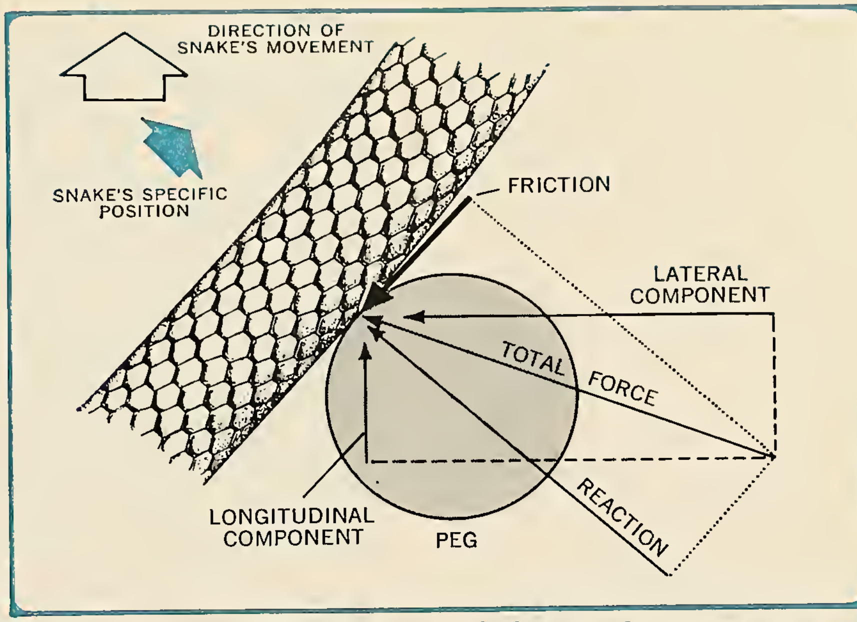


with which the lubricant par-
s slip past each other.

n excellent demonstration of the
:t of lubricants is displayed by the
skater. The "frictionless" glide of
e over ice is not pure sliding fric-
. It is caused by the lowering of
freezing point of water as pressure
eases. As the narrow tip of the
e begins to exert weight upon the
a narrow zone is loaded until its
zing point is below the temper-
e of the ice, which melts. Skate
surface are then separated by a
of water that lubricates and dras-
ly reduces the friction coefficient.

now becomes possible to take a
ook at actual patterns of locomo-
. We know from the fossil record
all terrestrial vertebrates derived
ı some kind of fishes, and the loco-
or pattern of fishes possesses cer-
aspects that reflect on the patterns
in more advanced forms. There
ome argument among ichthyolo-
s whether the kind of undulating
motion seen in an eel, and often
sidered typical, is truly primitive,
e it has been suggested that the
iest forms must have propelled a
tively stiff anterior head and body
curving, lateral movements that
e restricted to a more flexible tail.
ing evolutionary processes, such
:al movements extended anteriorly
he body armor regressed or the
y became more elongate.

ail wagging was caused by alter-
: contractions of the left and right
cle masses. As the zone of bending
ame longer, there would have been
ndency for a sequence of contrac-
, rather than simultaneous contrac-
, of the muscles on each side. Such
iential contraction of serially ar-
ged muscle units is common in
t lower vertebrates and inverte-
es, and reflects a fundamental pat-
in the muscle control mechanism.
s simplified "programing" now
ds staggered waves of muscular
:ractions that move from head to
The site of maximum contraction



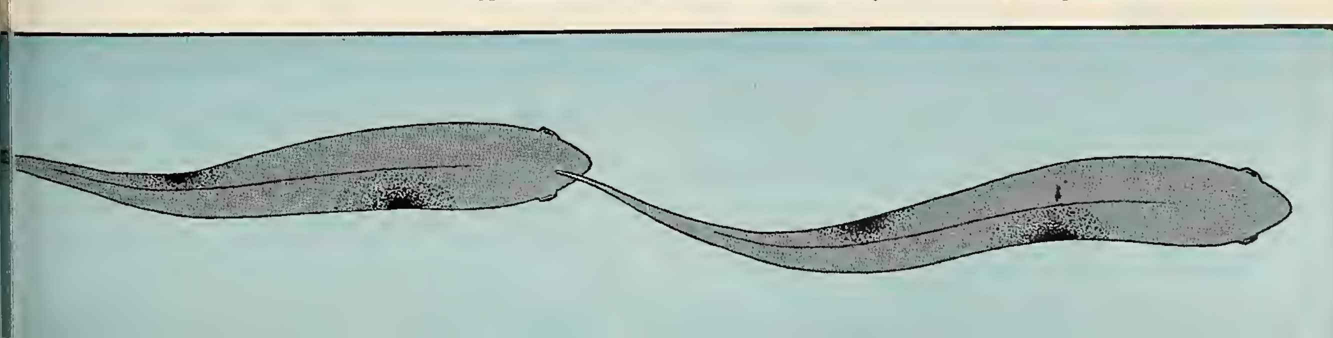
TOTAL FORCE, as snake moves by peg, is result of reaction and friction— the lateral and longitudinal portions. Latter will decrease as friction rises.

of muscle fibers always corresponds to the site of maximum relaxation, or stretching, of the units of the opposite side. It is obvious that the zone of maximum contraction will generally correspond to the portion of the trunk that shows the greatest concave curvature. In fishes, the axial muscle fibers are relatively short. They attach to myocommata, or connective tissue plates, that run out in a complex pattern from the level of each vertebra. (Their arrangement can be studied while dissecting a broiled trout.)

When the fish is relaxed, the muscle fibers generally lie in parallel with the long axis of the trunk. The bending of the trunk occurs by a principle that has been likened to the bending of a bimetallic strip. Two plates of different metals are pinned together at their ends. As one changes its length relative to the other, for instance, the combination bends toward the shorter one because of different coefficients of thermal expansion. Similarly, the trunk bends toward the contracting side. The folding of the muscle septa, then, relates to matters of muscle packing and to other structural considerations, and is not directly involved in the bending process.

What is the nature of the forces that propel the fish? As its tail swings from left to right (in the most simple situation), its posteriorly pointing surface tends to displace or exert a force against the water. This force is induced in direct opposition to the moving side of the tail, which is then at an angle to the direction of the animal's long axis. The force, summed up from all the tail areas involved in displacing water, may be resolved into a vector at right angles to the animal's long axis, and one in parallel with it. The reaction to the first will tend to swing the fish's body about its center of gravity; the second is the propelling force. The former force may be compensated for by medial stabilizing fins that reduce the swing of the fish's

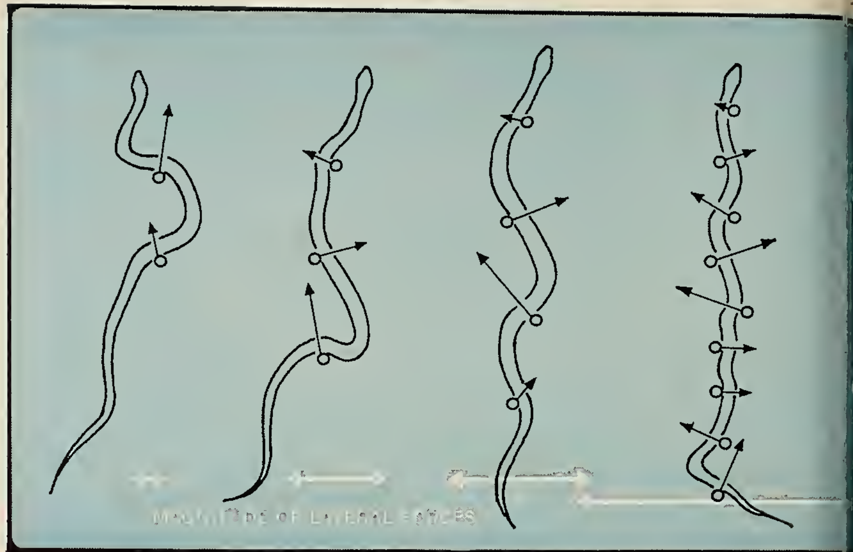
FOUR VIEWS show that curvature of fish's body is produced by muscle contractions that move alternately down sides from head to tail. The reaction to backward movement of the waves pushes the fish forward.



head, or the body may form two or more waves that push against the water simultaneously, so that the resultants compensate to some extent.

While the force induced at the moving surface is theoretically at right angles to the direction of motion, it is almost always deflected by surface drag or friction. Since the tail is sweeping through a fluid, the friction is relatively low, but it is nevertheless important, particularly when the fish moves at high speeds. The frictional force provides a vector that acts in parallel, but opposite, to the force inducing motion, thus reducing the drive and requiring additional energy for equivalent propulsion.

Quite early in their evolution, fishes developed paired lateral fins, apparently for steering; fins that later served for propulsion. At some point these fins became modified into limbs, providing one of the adaptations that permitted the successful invasion of land—a fascinating story that we cannot go into here. It is interesting, however, that the basic movements of these limbs were controlled by a modification of the old sequence of alternating contraction waves—a sequence that stayed in the animal's nervous system.

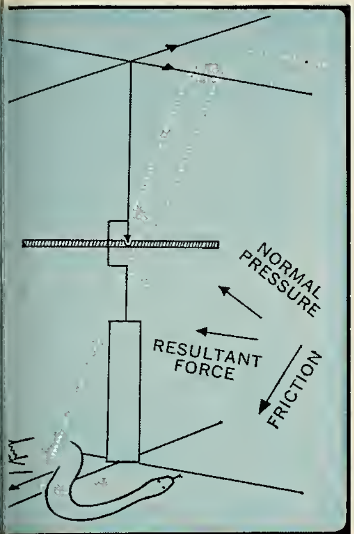


Different number of indicator pegs, like that at far right, influences the forces exerted by a snake in cont with them. Note that the magnit

It is generally supposed that the earliest terrestrial vertebrates pushed themselves out of the water on their bellies, as do salamanders and some fishes. The propulsion force was furnished by the ends of the limbs that scraped along the surface. The frictional force available for each foot was then proportional to the force pressing foot against ground, or to the portion of the animal's weight lifted by the limb at the time. Since the lifting of the animal's body also reduced sliding friction between belly and ground, there existed a double selective advantage for muscles that could lift the trunk during the entire locomotor sequence. Such lifting required balance, and the coefficients of static friction are always higher than those of sliding friction, so there were then two further advantages for maintaining the ends of the appendages in fixed contact with the ground. These were probably the major factors that produced the selective advantage for a more effective walking sequence.

At this point the perceptive reader is undoubtedly asking about the need for this digression. After announcing our intention of analyzing limbless locomotion we have taken an aside into the problems of locomotion *with* limbs. The reason is simple. The structure of an animal cannot be unde stood by examining only its prese functions, mainly because the stru ture retains remnants of past fun tional influences. Because the stru tures that an animal may utilize a modify through natural selection mu already be present when the ne arises, past selective needs and pa structures remain important to o understanding. An example is giv by the paired fins, whose existen provided a simple set of structures th could be modified into walking limb

A less obvious case derives from t need for raising the trunk above t ground while the animal, no long buoyed by the water, is exposed to t full effect of gravity. This need furth complicated the tasks of the verteb column, which in water had to res compression and bending, but lit



e lateral forces increases with
umber of pegs that are touched.

ar or torsion—forces that tend to ft the axis of a section of the column tically or laterally, or those that d to twist that axis. The different ds of cantilevering and other types suspension from the shifting, asymtrical, supporting points of the bs gave the animal the capacity to hstand shear and some torsional ces. This selective need was met by fusion of what were originally sely articulated components into a ies of vertebrae, and by the hyperphy of various lateral articulations ween successive vertebrae. These nges allowed highly controlled ds, making possible such later spe- izations as constriction in snakes ATURAL HISTORY, June-July, 1962). While certain of the vertebrates util- l their limbs for invading the land, ne of their descendants lost their limbs after the successful invasion. This loss seems to have occurred under only three headings: modifications for swimming, modifications for moving through grass tufts, and modifications for burrowing. These share three characteristics: the loss of limbs occurred in response to a need to streamline the trunk: the trunk became more elongate: its axial muscles took on some of the tasks of locomotion. Yet only selection for burrowing is generally assumed to have led to animals that have lost their external limbs completely. Here belong some or all of the caecilians, snakes, amphisbaenids, and lizards.

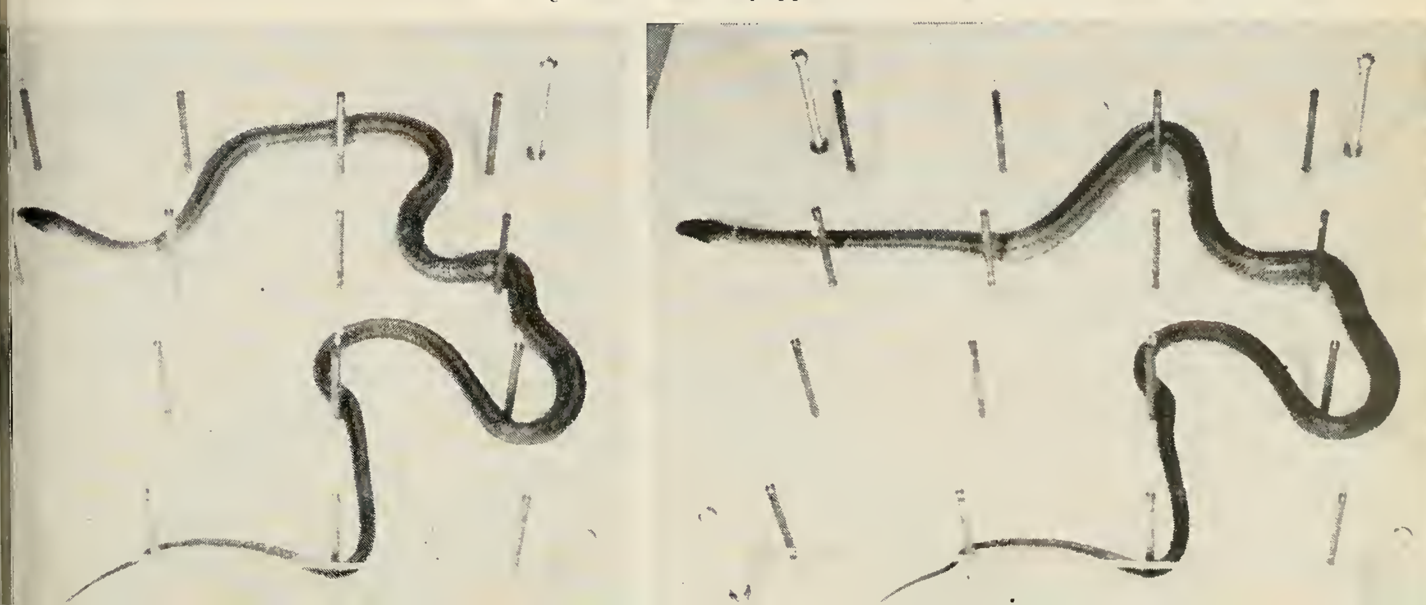
All of these limbless or near-limbless forms can move by lateral undulations. It is thus an obvious assumption that this is the basic or primitive pattern, particularly as it is also found in a variety of limbed, but elongate-bodied animals such as skinks, and in such animals as crocodiles, which use it during their downhill escape movements. Further support for the assumption is provided by eels, which use lateral undulatory motion when on land, and by snakes, which generally shift to the fish type of undulation when they enter the water.

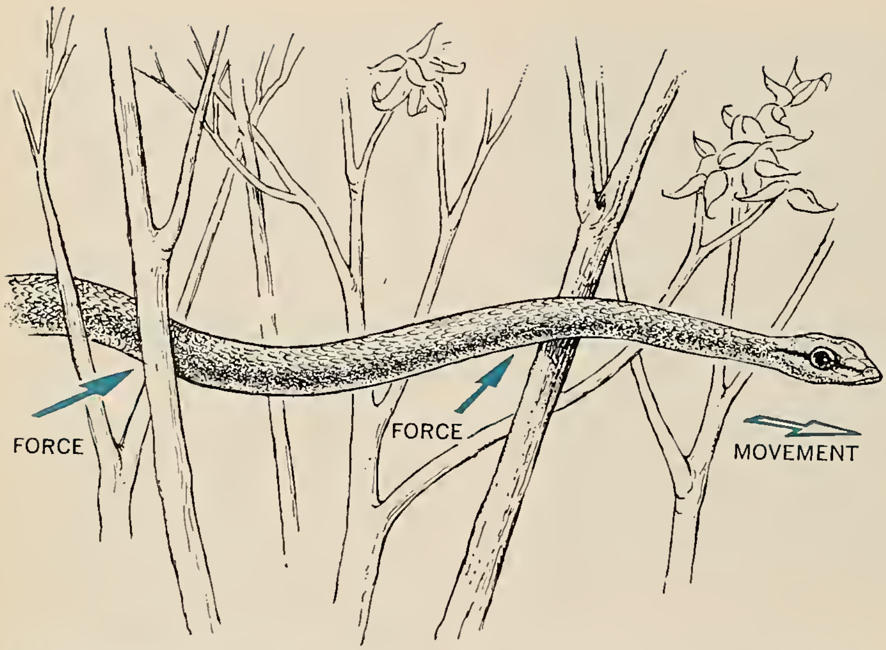
Lateral undulatory motion on land is similar to that described for elongate fishes. Both are based upon alternate waves of muscular contraction that pass down the sides of the animal. However, in the terrestrial pattern the bends are markedly influenced by the topography of the ground instead of being of constant amplitude. Both lateral contact and locomotor force application are restricted to specific sites, rather than being continuous over the posteriorly facing aspect of the animal. The most casual observer can distinguish between this contact and force by noting the difference between the rate at which waves travel along the animal's body and the rate of travel of the animal itself. In fishes, the former is always faster. In contrast, a snake moving in a constant direction across a horizontal pegboard sets up a definite pattern of curves ordinarily traced by every part of its trunk. Superficial inspection will not indicate any motion at one particular fixed point; only the head and tail show obvious movement. When a unicolored or striped snake travels in tall grass, where only part of its body is visible at any given moment, it does not give an impression of motion even when passing at high speed.

THE forces exerted during lateral undulatory locomotion are of two kinds. The animal's weight induces forces upon the substratum via the ventral surface. Since the snake's mass is constant, the frictional force induced by the weight may only be varied by modifying the coefficient of friction between the ventral surface and the ground. This selective effect seems to be responsible for the development of the smoothly overlapping ventral shields of the various forms that use this method for surface locomotion.

The propulsive forces of lateral undulatory motion are exerted at the points at which the sides of the animal touch lateral irregularities in the environment. That propulsive forces are exerted only against such vertical and

MOTION-PICTURE stills show a snake moving across a board equipped with low-friction indicator pins. Even a slight contact causes pins to rotate.





Arboreal snake may use same contact points to exert forces that support and accelerate its body as it moves in direction shown by the open arrow.

laterally placed contact points can easily be shown by placing a startled snake on a very smooth surface. It will go through a rapid lateral undulatory sequence. As in a fish, the waves will, however, pass down the trunk at a rate much higher than that of forward progress, which will be zero. At their contact points, the body curves, or loops, will exert forces directed at some angle to the direction of motion. Such forces will be resolvable into two component vectors, one parallel to the direction of motion and the other at right angles to it. Only the first will tend to accelerate the body or to counteract the sliding friction between ground and ventral surface. The components at right angles tend to swing the animal's body horizontally. Unlike those of a swimming animal, the components directed left and right need not compensate perfectly; they would have to overcome at least the effects of sliding friction before they could move the body. The relative proportions of the two vectors, along the direction of motion and at right angles to it, will be adversely affected by friction at the contact points; friction is thus again disadvantageous. The effectiveness of lateral undulatory movement also decreases as the vertical discontinuities against which the animal is pushing become more nearly parallel to the direction of motion. The individual loops must transmit the forces posteriorly, rather than laterally, so they must contact these sites along their anteriorly facing sides. A snake is thus unable to travel by lateral undulatory locomotion either across a smooth, even surface or down a narrow passage or tunnel restricted by straight, parallel sides.

Some years ago, J. E. Gray and H. W. Lissmann of Cambridge University designed an elegant apparatus demonstrating these facts and simultaneously indicating the force exerted at each contact point by an animal traveling by lateral undulatory locomotion. They suspended a regular grid of pendulums over a smooth plate that would offer minimal friction with the ventral scales of their snakes. The magnitudes and directions of the movements by the pendulums, or suspended pegs, were directly proportional to the magnitudes and directions of the forces exerted by the loops contacting them. Motion pictures of snakes traveling across this surface gave excellent indications of the size and direction of the forces exerted during progression.

These and some other experiments confirm that snakes have a remarkable latitude in their selection of the numbers and sites of fixed points. During progression, the animal's anterior end forms alternating bends that travel laterally until they touch objects whose deflection with applied force is sufficiently low to meet some sort of internal standard. Actually there is minimal information about the criteria utilized by an advanced limbless form, such as a snake, in its selection of the number of points against which it will induce propulsive forces, in its determination of the sites where it will form standing loops, and its characterization of the number and the diameter of the loops. We know even less about the effect of any and all of these factors on the animal's rate of energy consumption during travel. A few preliminary observations do suggest that the rate of energy expenditure goes up with the number of lateral contact points.

The axial musculature of the various limbless forms has been drastically modified. Instead of masses of short muscle fibers, as in fish, each corresponding in length to that of a vertebra (or rather to the distance from the center of one vertebra to the center of the next), one observes complex and involved patterns, some characterized by muscles arranged in series and spanning fifteen or more vertebrae. It is tempting to generalize that these arrangements permit long smooth bends of the trunk, but we actually know next to nothing about the detailed ways in which they function. Only the general structural patterns of this exceedingly complex system have been described thus far.

Snakes and some lizards have modified the lateral undulatory method and use it when traveling through dense grass and over inclined branches. Here the animal's ventral surface need not make direct contact with a substratum but the weight can be transmitted and the propulsive force induced diagonally through two or more identical contact points. While the analysis of forces is slightly more complex in such a system, there is little fundamental difference between it and the regular lateral undulatory pattern. What is required for its successful use is probably a slightly greater level of nervous control. This is particularly true for those elongate tree snakes that seem to move at high velocities through bushes and the tops of trees, always resting in seemingly precarious balance at angles to a succession of swaying twigs.

(*To be concluded in March*)

Black rat snake uses concertina lateral undulation movements to climb. Force is exerted laterally by snake's ventro-lateral keels on b

Lush growth of plants that have come from around the globe can be seen through arch of the ancient abbey.

Subtropic Flora Thrives on 50th Parallel

THE Isles of Scilly comprise an archipelago of more than two hundred rock formations in a 45-square-mile area. Of these, only forty can be called true islands. They are located on the 50th parallel, 28 miles southwest of Cornwall on the English mainland. At the present time, only the five largest islands are inhabited: St. Mary's, Tresco, St. Martin's, Bryher, and St. Agnes. The total population of the islands is 1,800, of whom some 300 live on Tresco, the second largest and, possibly, the most interesting of the group.

From evidence gathered in archeological excavations, it is thought that the Scilly Islands probably were known to the Greeks and Romans. They may have been the Cassiterides of the Phoenicians or the Hesperides of the Greeks—both reported as "tin islands," when tin was mined in Cornwall. Herodotus spoke vaguely of the islands in the fifth century B.C.; later they were mentioned by Poseidonius, Strabo, and Diodorus.

King Athelstan conquered the Britons of the west in A.D. 925, and about three years later brought the islands under his rule; on Tresco he established the Benedictine cell of St. Nicholas. Later in the same century, King Olaf of Norway visited Tresco and, according to tradition, was converted to Christianity by a hermit. The recorded history of the islands began in the reign of Henry I. The earldom of Cornwall held approximately half the lands of Scilly from the beginning of the fourteenth century, and in 1547 sold them to Sir Thomas Seymour. Through him the moiety fell to the crown. The islands sheltered Prince Charles in 1645 during the Civil Wars, and remained a Royalist stronghold until the Restoration. Fortifications were constructed as the islands gained in military importance during the numerous wars with France and Spain in the sixteenth and seventeenth centuries, and when Spanish ships followed the new trade routes to the New World.

When the tensions eased between England and her continental neighbors, the islands retreated into obscurity. The inhabitants became occupied with fishing, farming, and, more particularly, with their main industry of burning kelp, an essential in the manufacture of soap and glass.

In 1687 the whole of Scilly was granted to the Godolphin family. The lease was renewed once before a dispute arose between the Duke of Leeds, a descendant of the Godolphins, and the lessor, the

by E. JAVORSKY

Main abbey and garden entrance are at the end of drive lined by jungle-like border of rare shrubs and trees.

Panorama of subtropical growth, *above*, makes island appear to be near Equator instead of off English coast.

From the top terrace, "Neptune" faces southward to the sea and the two islands of St. Mary's and St. Agnes.

Temperate climate is caused by direction of the North Atlantic Drift, northeastern current of the Gulf Stream.

Walled garden east of the abbey ruins contains banana trees, *below,* with auratum lilies growing beneath them.

The Growth of an Idea

duchy of Cornwall. Dissatisfaction with the duke's administration led to the appointment in 1831 of a new Lord Proprietor, Augustus Smith, a young man who owned considerable property in Hertfordshire and Buckinghamshire. Under the crown he held a 99-year lease for which he paid 20,000 pounds, 40 pounds annual rent, and "some stipends." Why Smith became particularly attracted to Tresco is not known, but he built a house there near the ruins of the old Benedictine abbey.

In 1843, he inadvertently started the Tresco Abbey gardens. Until that date, Tresco had been without a tree or a bush. The new landlord began to search for plantings that would stand up against the strong winds and salty sprays of the Atlantic. He gradually found them, and under their protective cover, small farms and lush foliage began to prosper. He carried out many recommendations suggested by the duchy of Cornwall, but for the most part he applied his own ideas of reform. Some of these were far in advance of the times. For example, he brought a compulsory educational system to the islands more than forty years before one was introduced on the mainland. Courses included reading, writing, arithmetic, the Scriptures, geography, and history. Smith was proud that his people could read and write. However, he enforced his ideas tyrannically, and apparently he was heartily disliked.

Mr. T. A. Dorrien-Smith, who was Augustus Smith's nephew and heir, continued to create new and better living conditions through economic developments. He established commercial flower growing, going to Holland to purchase large numbers and varieties of bulbs in order to find the species that would grow best on Tresco. At the same time, a

Horticultural Accident

Bright orange *Alstroemeria, above*, comes from Mexico. Flattened against a wall, *left*, are giant houseleeks that form a blanket of gray-green rosettes. The taller of the two palm trees, *Dasylirion acrotriche, right*, is about 120 years old. Seen directly behind the palms are specimens of the subtropical monkey puzzle tree, *Araucaria araucana.*

fast-growing and wind-hardy specimen of Monterey pine (*Pinus radiata*) was planted to protect the wind-blown fields. Today, growing and propagating daffodils is one of the most important of the island industries. During February and March, all English cities are supplied with Soleil d'Or, Magnificence, and Scilly Whites from neat fields edged with clipped hedges of karo (*Pittosporum crassifolium*), from Australia, and the spindle tree (*Euonymus europaea*), from southeast Asia, which provide shelter.

In 1929, Major A. A. Dorrien-Smith, who inherited the property, signed another 99-year lease (now held by T. M. Dorrien-Smith). During his leasehold, the fruits of the previous years of labor and experimentation began to show, and Tresco Abbey gardens started to acquire their present subtropical magnificence. Major Dorrien-Smith, who eventually became a noted horticulturist, sailed to Australia, New Zealand, and South Africa to bring home more trees and shrubs that would flourish on Tresco—and flourish they did, although the soil is sandy and the annual rainfall is just 32 inches. The reason is the North Atlantic Drift, which encircles the archipelago and is responsible for the mild climate and the gently cooling breezes that bring in the moist air required for the success of subtropical vegetation. The temperature on the islands ranges from 71° to 35°F., and seldom drops below the latter point—a rare condition indeed on the 50th parallel, which on the North American continent runs through Winnipeg, Canada. The northwestern shoreline of Tresco is mostly rocky, but all of the southwestern and eastern parts of the island are edged with beaches of sand as white and fine as that on islands in the Caribbean. In the abbey gardens one finds a unique collection of flowers, shrubs, and trees from all corners of the Southern Hemisphere. Here grow varieties of the cabbage tree (*Cordyline*) from New Zealand, and the bottlebrush (*Callistemon*) from Australia; the great borages (*Echium*) from the Canary Islands and Madeira; the cape olive (*Elaeodendron capénse*) from South Africa; a South American species of the monkey puzzle tree (*Araucaria braziliana*); huge succulents—aloes, agaves, and yuccas from Mexico; palms (*Chamaerops excelsa*) from China; Grecian lavender (*Lavendula stoechas*) from the Mediterranean; and aromatic blue rosemary (*Rosmarinus* sp.) from the hills of Tuscany. These are only a few of the hundreds of plants from many continents that grow here and propagate freely.

The charm of the abbey gardens makes them a mecca for horticulturists, plant lovers, or simply those people who wish to escape—even temporarily—from the cares and tensions of day-to-day living.

Early Mapping of the Land and Sea

ASTRONOMY WAS THE KEY

by GEORGE A. ROTHROCK

For centuries, men have recognized the usefulness of maps. Although no examples of ancient Greek maps survive, Herodotus, Aristophanes, Democritus, and Hipparchus all mentioned them, and by the time of the birth of Christ a number of geographic and cartographic theories had been advanced.

The most notable of the ancient map makers was Claudius Ptolemaeus, better known as Ptolemy, whose labors spanned the years from about A.D. 127 to 151. Mathematician, astronomer, and geographer, he also wrote on astrology, music, and optics. This versatile, early scholar produced two books of great significance to Western scientific thought—the *Almagest* and the *Geographia*. The former dealt with the earth's position in the universe and was one of the primary foundations of geocentric theory; the latter was a comprehensive geography of the known world.

Ptolemy's *Geographia* was not highly original in concept. Chiefly, he organized earlier ideas into a comprehensive system and then applied that system. He borrowed the idea of latitude and longitude from Hipparchus; from other writers he adapted a list of geographical names. In the sixth century B.C., Pythagoras had advanced the theory that the earth was a sphere. Slowly his hypothesis won adherents, and a number of the ancient Greek astronomers and philosophers attempted to estimate the earth's circumference. In the third century B.C., Eratosthenes, an able student of science, made a calculation based on sight angles of the sun from points that were a known distance apart on a north–south axis; he produced a measurement of 25,000 miles (the circumference actually is 24,902.39 miles at the Equator)—a remarkable result, considering the limits of his instruments. Little more than a century later, Poseidonius attempted a similar measurement, using a star as his reference point. Although there were some problems in the experiment beyond his understanding, a reasonably correct result was announced: approximately 24,000 miles. However, Ptolemy took the reports of these experiments (which he did not verify) from Strabo, a writer of the early first century A.D., and Strabo had erroneously reported Poseidonius' figure as 18,000 miles. Ptolemy copied the error and used it as the basis for his geography. This error—one of several that made many of his later conclusions defective—vastly contracted the earth, and played no small part in launching the voyage of Columbus 1,350 years later!

Ptolemy's summary of the role of the cartographer was "to survey the whole of the world in its just proportion." This necessitated observations and mathematical calculations, and Ptolemy used both. He established a prime meridian near the Canary and Madeira island groups, the westernmost known land; he then worked eastward from this meridian. At the same time, using travelers' estimates of distances, he calculated westward from his own city of Alexandria in Egypt. With an astrolabe—a primitive ancestor of the sextant—to determine latitude, and only dead reckoning to estimate longitude, Ptolemy established the positions of eight thousand places. In the Mediterranean, his inaccuracies were minor—chiefly the errors inherent in dead reckoning. But distortions increased with the distance from Alexandria,

as he relied on travelers' accounts r
more distant places. Furthermo,
underestimation of the earth's c-
cumference magnified his mistak.

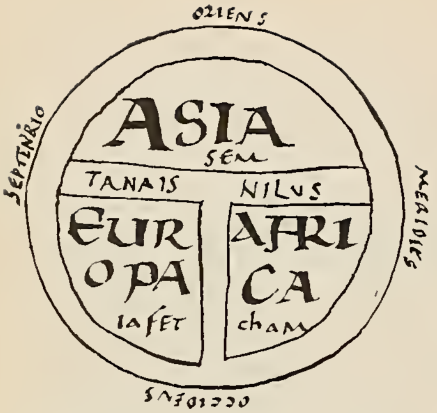
Despite these limitations, the G-
ographia was a monumental achie-
ment. From it derive such cartog-
phic practices as orienting maps w
north at the top, establishing lo-
tions by latitude and longitude, a
employing conic, spherical, orthog-
phic, and stereographic projectio.

Ptolemy's work, like so much

Map by Mercator included examples of perpetuation of scientific error, caused by Ptolemy's use of miscalculations made by earlier mathematicians.

[cut off]e intellectual product of the classi[cut off]l world, was lost with the decline [cut off] Roman civilization. It was not [cut off]ain influential until the mid-fif[cut off]nth century, when it was rediscov[cut off]ed and rendered into Latin. At that [cut off]ne, Ptolemy's reputation was al[cut off]ady solidly established, for his [cut off]*magest* had been reintroduced to [cut off] West in the twelfth century and [cut off]s considered authoritative. Hence, [cut off] cartographic system spread rap[cut off]y, especially after the printing press and engraving techniques made illustrated editions possible. In 1477, an edition of *Geographia* was issued with maps printed from copper plates, and in 1482, another edition —including some "modern" items— was published with maps done from woodcuts. By 1500, seven folio editions had appeared, and thereafter even collections of new maps announced themselves to be "after the manner of Ptolemy"; usually they included copies of maps "ascribed" to Ptolemy to give the books authority.

Meanwhile, what of the thousand-year gap between the decline of Rome and the rediscovery of Ptolemy? For the most part, medieval maps were either highly diagrammatic or were simply stylized sketches, with little or no scientific basis. Three-cornered diagrams of the earth were used to represent the three continents (Europe, Africa, and Asia), the three seas, and the Christian Trinity. Four-sided maps



T in O map is from a tenth-century Latin manuscript, and was the common form for world maps in Middle Ages.

were also used, symbolic of the four sides of heaven and the Four Gospels. These must have been of small help to travelers.

Also popular in the Middle Ages were "T in O" maps. The evolution of these is not altogether clear, but they were based on a form that existed before Ptolemy. These were circular maps oriented with east at the top. Despite the improvements inherent in Ptolemy's work, circular maps had continued to be widely used among the Romans. The medieval T in O probably derived directly from stylized copies of these Roman maps; the transformation is quite comprehensible. A circular map of the Mediterranean and Roman world with east at the top produced a rough T set in an O. The Mediterranean formed the upright of the T, while the Don and Nile rivers formed the crossbar. The whole was surrounded by the "ocean-sea," which was assumed to enclose the land mass and cover most of the earth. Unless one were willing to believe that mysteries were usually coincidence, and few men were willing to admit that, there was a mystical significance to the T in O form; the world wrote its own initials, *orbis terrarum*.

Not all medieval cartography was so naïve, but improvements were usually of a limited nature. There was no attempt at anything with the scope of Ptolemy's descriptions. Some travel maps of undetermined origin were used, especially after the stimulus of the Crusades; these usually took the form of "ribbon maps." A road was represented, usually in a series of parallel strips, so more could be placed on a single sheet; on the road would then be located the various castles and towns that a traveler would see in getting from one place to another—from London to Jerusalem, for example.

Another practical development was the production of compass and portolano charts. The first of these appeared about 1300, probably the product of the great seamen of Genoa. Essentially, they were coastal charts, on which several compass roses were drawn, and were definitely the product of practical seamen, not of academic geographers. (Compass roses are simply compasses drawn on maps, usually at a port or landfall from which a mariner can select a course to his next landfall.) It is not known exactly when or where the compass was first used, but by the twelfth century it was becoming a common device for navigation, and the addition of compass roses to coastal charts of this period produced a useful navigational aid, although they gave no accurate indication of latitude or longitude.

When Ptolemy's *Geographia* was rediscovered, the scope of the work, the reduction to system, the symmetry and order, were all rather breath-taking. The success of the *Geographia* doubtless owed much to factors that were really irrelevant—the growing enthusiasm for anything classical and the author's well-established reputation based on the *Almagest*. But when Columbus sailed west, the *Geographia* was still far superior to any other guide.

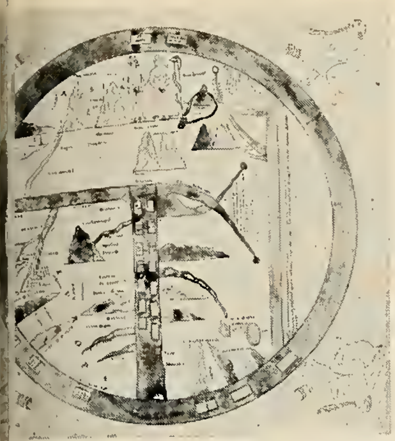
One has only to consider the maps of a late medieval cartographer, Leardo, which were executed in the 1440's and 1450's, to understand Ptolemy's continued popularity. If the general acceptance of Ptolemy may be considered the beginning of modern cartography, the Leardo productions might fairly be called the last medieval maps, for they were only slightly influenced by Ptolemaic ideas. Jerusalem stands at the center; the land mass is circular, with east at the top and water all around. The *Geographia* had been rendered into Latin shortly before Leardo's time, and he must have known it, for he borrowed from it a few place names and some rivers in Asia that were not present on earlier European maps.

Then, in the sixteenth century, a number of important things happened to map making. More or less simultaneously, Ptolemy's *Geo-graphia* was widely circulated, ad-vances in printing and engravin-made possible the accurate reprodu-tion of inexpensive maps, and voy-ages of discovery produced a weal- of new geographical knowledge.

By the mid-sixteenth century mo- geographers realized that the Ptol-maic map needed revision, but fe- assumed that major modificatio- were necessary. Rather, most b-lieved that Ptolemy was reasonab- accurate in regard to the know world of his day; hence, what w- needed was to extend his map to i-clude newly discovered lands. Son evidence was accumulating, howeve that posed a fundamental challen- to Ptolemaic geography. In 157 Sultan Murad III of the Ottom- Empire had his lands surveyed, a- he discovered that Constantinop- was two degrees farther south th- Ptolemy had stated. Some argumen- were advanced that the earth's a- had tipped since Ptolemy's observ-tions, but these were refuted wh- other points of latitude were check- and agreed with the ancient calcu-tions. In the case of Constantinop, Ptolemy simply had been wrong.

Until the middle of the s-teenth century the Itali- cities remained the chief centers f map production, but in the latter h- of the century the focus of the tra- shifted north to the Low Countri-, first to Antwerp and then to Amst-dam. This shift, of course, reflect- the development of ocean explo-tion. News of geographical d-coveries came first to the Atlan- ports—to Antwerp when the Neth-lands was a dependency of t- Spanish crown, and then to Amst-dam as the Dutch developed th- own empire. It was in these northe- cities that a number of famous c-lections of maps were issued—m-t notably the *Theatrum orbis terrar-* of Abraham Ortelius (about 157-) and the significant *Atlas* of Gerar-s Mercator (in 1595, a year after -e author's death).

As late as the sixteenth and ea-y seventeenth centuries, however, -e problem of longitude posed a se-ingly insuperable obstruction to p-cision in cartography. Instrument- of sufficient quality existed to estab-h latitude fairly accurately from ce-tial observations, but no one -d



'welfth-century map shows east 'ith Adam, Eve, and serpent at the top, nd the four winds in the corners.

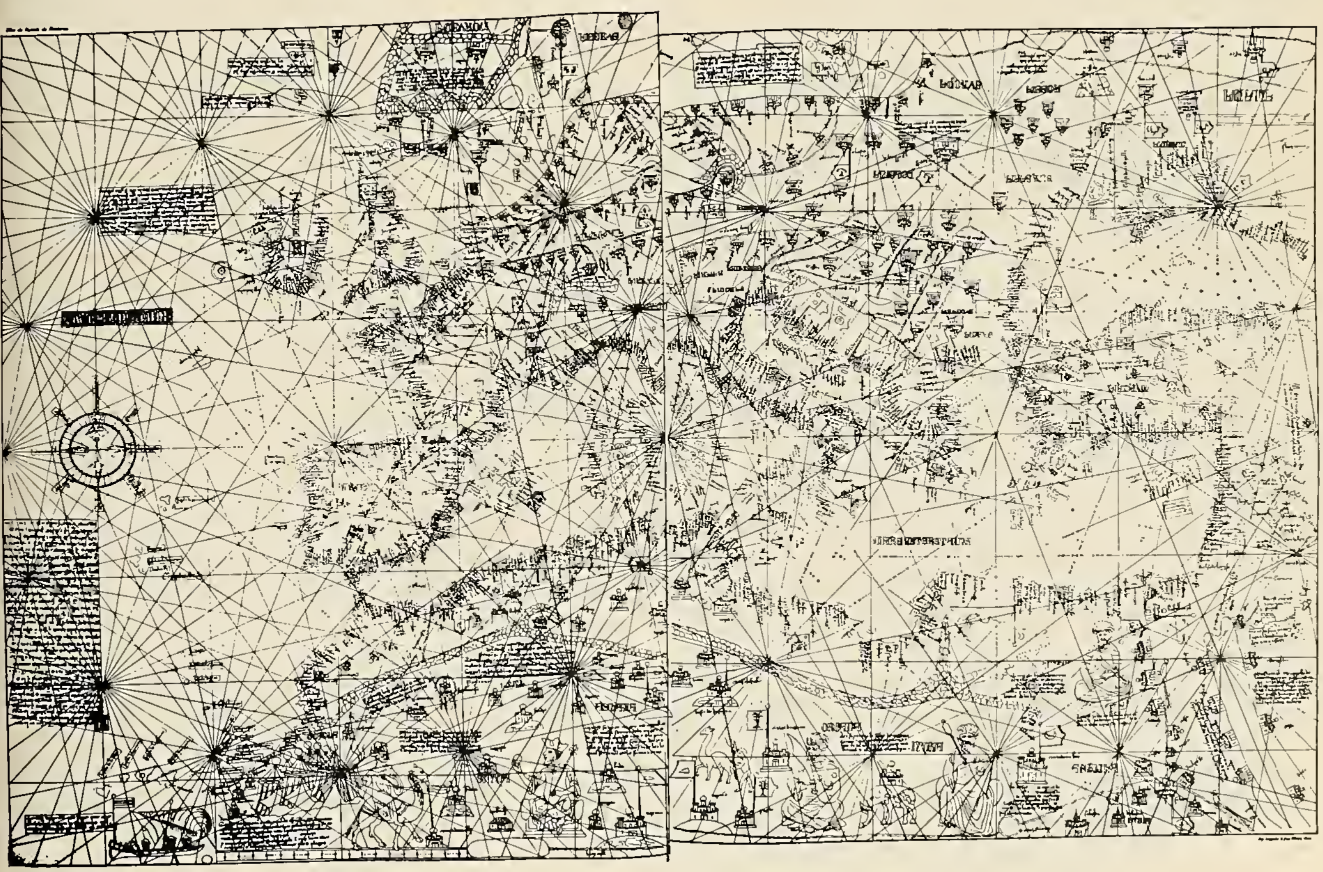
een able to devise a simple system to stablish longitude, let alone to in- ent and refine instruments. Com- ounding all these difficulties, the xact size of the earth remained un- nown, and there was no generally ccepted prime meridian. (A com- non solution to the latter problem vas to use one's own capital city.) In he early seventeenth century a num- er of tables of the latitude and ongitude of various cities were published, but no two of these agreed.

Lacking reliable longitudinal calculations, cartographers could not accurately map the newly discovered lands and oceans. Princes, claiming new discoveries or concerned for their shipping, were disturbed by this, and offered prizes to encourage the development of a means of finding longitude. In 1598, King Philip III of Spain offered a lifetime pension and a handsome purse for an effective method, and smaller prizes simply for an idea that might prove helpful. Although he was deluged with plans, none at first seemed practical, and by 1616, when a valid project was suggested, the surfeited king refused even to consider it.

There were attempts to use the compass to determine longitude by plotting its variations from true north, as determined by celestial observations. But changes do not occur uniformly, and the lines of variation do not always run north and south, so this, too, proved impractical.

Astronomers sought an answer in the skies, and tried to find a heavenly body that could serve as a point of reference. There were some attempts to utilize lunar eclipses, but they were too infrequent and developed too slowly to be of much use. As early as 1610, Galileo had suggested a more practical reference point. He had discovered three of the moons of Jupiter, and he realized that their eclipses —which occurred almost nightly— would be much more useful than the one or two annual lunar eclipses. He found that he could plot the positions of the satellite moons several months in advance; then, by observing the eclipse from some other place and comparing it to his preplotted tables, he could establish the time differential with some exactness.

This major key to the problem of longitude was the project submitted to the great Spanish competition in 1616, but Galileo failed to gain its acceptance, despite a long correspondence on the subject with the Spanish royal commissioners. In the long run, Galileo probably made a more significant contribution to the development of longitudinal calculation through his experiments with telescopes and pendulums. As perfected by Christian Huygens, the pendulum clock was an accurate timepiece in any fixed position. In brief, pendulum clocks were used, as were lunar



Map of 1375 was meant to be read from two sides. Compass roses enabled mariners to plot their courses without longitude.

eclipses, in establishing a set time period against which local time could be compared and the difference translated into degrees of rotation.

The combination of astronomy, mathematics, and royal policy finally produced scientific cartography in France in the latter seventeenth century. The goal was still that of Ptolemy: to locate places by latitude and longitude; "to survey the whole of the world in its just proportion."

Until the middle of the seventeenth century the scientific revolution had been largely a matter of isolated investigators working at private projects on their own resources or with the help of patrons. They often lacked recognition; they usually lacked resources; most of all they lacked communication with one another. The foundation of the Royal Academy of Sciences in Paris, in 1666, put France very much into the race for scientific achievement. Through the latter part of the century, scientists gathered here, were given the best instruments available, and Louis XIV paid the bill.

Although the T in O pattern is gone, the land mass is still circular; east is still at top. This world map of 1448 is by Leardo of Venice.

The scientists of the Academy were interested in many topics, but one of the King's specific injunctions was to improve maps and sailing charts. The obvious problem was still longitude, and the Royal Academy group believed that extensive celestial observation was the most promising direction for research. The founding of the Academy, and the interest its members evinced in astronomy, crystalized another project that had been under discussion for some time —the construction of an observatory in Paris. Work on the new building was inaugurated in 1667.

Meanwhile, the men of the Academy had rediscovered the possible utility of the moons of Jupiter, which had been announced by Galileo fifty years earlier. Investigation led to another Italian, Giovanni Domenico Cassini (1625-1712), and he was soon invited to Paris. Born in a village near Nice and educated by the Jesuits in Genoa, Cassini was both brilliant and energetic. In 1650, when he was only twenty-five, he had been appointed Professor of Astronomy at the University of Bologna. Thereafter he had been called upon by the Pope and by the Senate of Bologna to resolve numerous problems in astronomy, engineering, and hydraulics. Honors—usually entailing hard work—were showered upon him. He was appointed Superintendent of the Waters of the Po; Inspector of Fortifications for Perugia, Pont Felix, and Fort Urbino; and Director of Waterways in the Papal States, while still continuing as Professor of Astronomy. His major interest, however, continued to be astronomy, and he was particularly fascinated by the planet Jupiter. With a telescope of greater power and better resolution than Galileo's, and an accurate pendulum clock, Cassini intensively studied Jupiter's satellites and prepared new tables of their eclipses. In 1668, after sixteen years of preparation, he published his work, *Ephémérides*. One of the most important results was the invitation to Paris.

The largest single technical problem now confronting the astronomers in Paris was the need for an accurate measurement of the earth. New celestial observations would be of little value in mapping if astronomically based calculations were related to an erroneous fundamental value. Hence, a detailed project was planned and, in 1669, work was begun under Jean Picard (1620-1682). Picard, a member of the Collège de France, was known for his work in astronomy and in instrument construction. He was to use the method of Eratosthenes, but with improvements and much more sophisticated instruments. He surveyed a north–south line by triangulation and then measured it by celestial observations. All subsequent calculations of the Academy were based on this new and very nearly accurate measurement. When Picard's work was done, Cassini assumed a primary role in the mapping projects. In the latter 1670's, he began work on a large-scale world map, 24 feet in diameter, which he called a planisphere. It was drawn on the floor of one of the towers of the new observatory on an azimuthal projection, with the North Pole at the center. Meridians radiated from the center at ten-degree intervals, and the parallels of latitude were laid down in concentric circles, also at intervals of ten degrees. Although this projection necessarily distorted land masses, it provided a good plan on which to establish precise locations of a number of places on the

earth's surface. Over the next few years Cassini dispatched small parties to distant parts of the world, and recruited the occasional help of men traveling for other reasons, to collect data. Results came in from Egypt, Madagascar, Siam, the Cape of Good Hope, Goa, the Orient, the West Indies, and the island of Cayenne off the coast of French Guiana.

The method used was relatively simple in its concept, although not without technical difficulties in its execution. The survey party would set a carefully regulated pendulum clock to local time, then use the eclipses of the satellites of Jupiter and precomputed tables to establish Paris time. The time differential could be translated into degrees of rotation between Paris and the point of observation, and with the new measurement of the earth the degrees involved could be translated into linear measurement.

Louis XIV, France, and the Observatory were well repaid for the cost and effort of recruiting Cassini. His Italian patrons had not wanted him to leave the country, and he had finally moved to France for what was supposed to be only a temporary stay. But in 1673 he became a naturalized subject of the King of France, and was thereafter known as Jean Domenique Cassini. He founded a dynasty of astronomers and map makers who directed the Observatory for a century and a quarter, for he was succeeded by his son, his grandson, and his great-grandson. The Cassini family mapped France, directed the preparation of important new sea charts, and was influential in the work that proved the earth was not a perfect sphere but rather was flattened at the poles. And the greatest fame must be attached to the founder of the Cassini family—Jean Domenique, born Giovanni Domenico, an international scientist, a naturalized Frenchman, a product of a great Italian tradition. But most important, he achieved the goal Ptolemy had set fifteen and a half centuries before him—he surveyed the whole of the world in its just proportion.

Copy of Cassini's planisphere is by J. B. Nolin, 1696. The original, 24 feet in diameter, was drawn on floor of the Paris Observatory.

Reclamation of Israel's

Photographs b

RAILWAY BRIDGE in the northern Negev forms a link in the railroad that takes Dead Sea products to the Mediterranean.

THE NEGEV, the desert that com prises the southern half of Israe has been described as "a land of shar contrasts . . . of delicate flowers an fierce bushes . . . of rain in scarcit and cisterns without number. . . Ranging from the northern Beer sheba Plain to the mountains of cen tral Negev to the sand dunes of th south, this desert forms a triangl between the Mediterranean Sea, th Dead Sea, and the Red Sea. It rises t an elevation of 3,395 feet in its hill western region and drops to 1,292 fee below sea level at Sodom in the east

Since the fourth millennium B. C. the Negev has been an important lin between East and West. Archeologist

FALLING LEVEL of the Dead Sea, whic has 25 per cent salinity and contain

Desert

'ETER MEROM

ave discovered four hundred ancient ites in the desert, and have deter-ıined that wars and economic catas-rophes—not the weather—have been esponsible for the disappearance of ivilizations. In Biblical times the Iegev was fertile and well populated, nd ancient water conduits have aided oday's irrigation engineers.

With a typical desert climate of a hort rainy season and a long, dry ummer, the reclamation of the Negev s a challenge to modern Israel. To ıake the land suitable for agriculture, ıdustry, and new settlement, pipelines ave been laid to bring water from orthern Israel. Ground-water springs re also exploited to the utmost.

BARLEY, planted by bedouins, grows in the northern Negev despite low rainfall. Irrigation is now being introduced.

large quantity of minerals, reveals rees that were killed by the water.

A Land of Barrenness and Fertility

DRIFTWOOD lies on the Dead Sea shore. The sea, at 1,292 feet below sea level, is Israel's greatest mineral source.

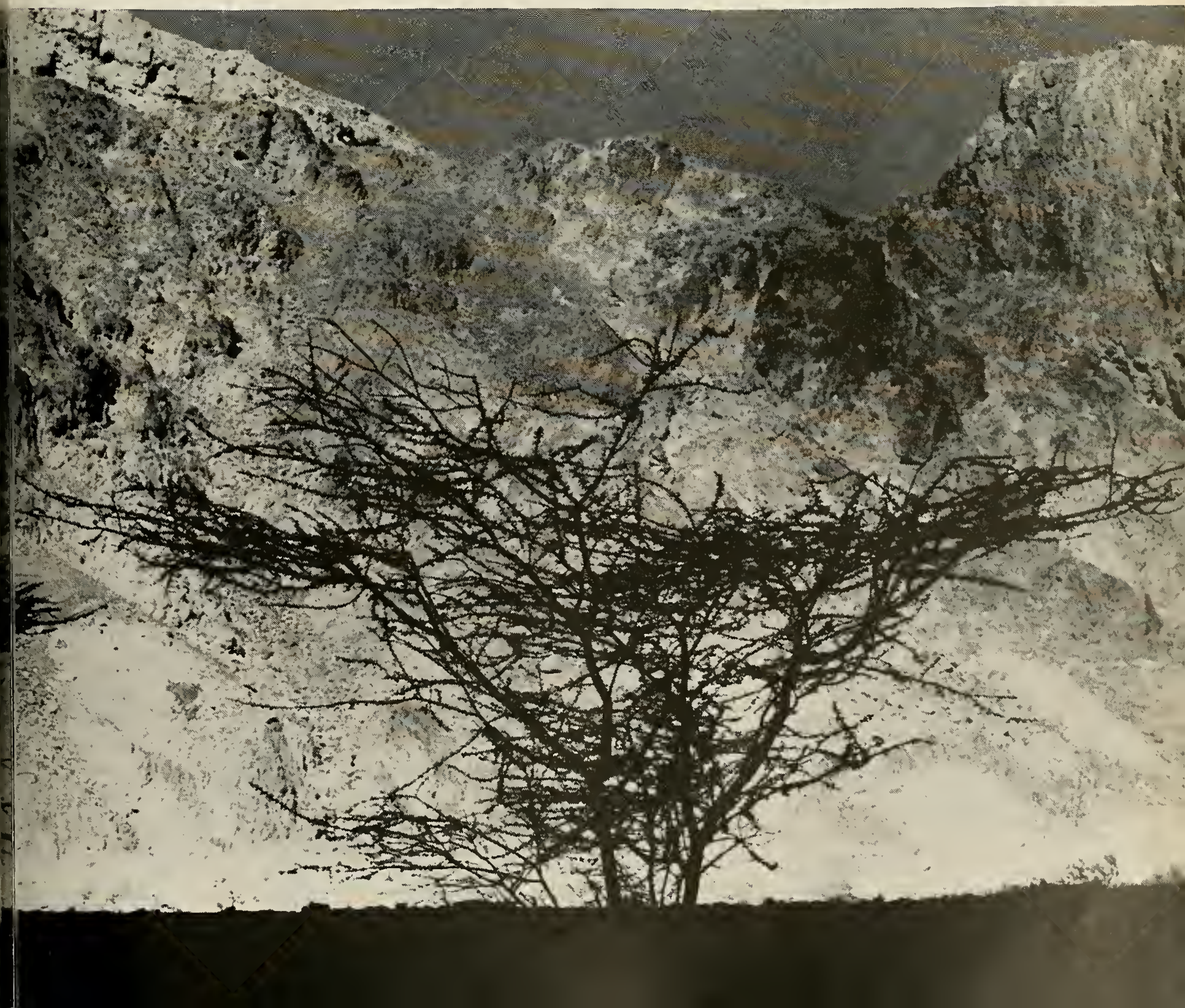
DESERT HORNED VIPER, *Vipera persica fieldi*, is found in the southern Negev. This is an extremely poisonous snake.

As for other natural resources, in Deut. 8:9, Israel is referred to as ". . . a land whose stones *are* iron, and out of whose hills thou mayest dig brass." Minerals found in the Negev today—often discovered through references in the Bible—include oil, gas, phosphate, iron, copper, gypsum, ceramic clays, and glass sand. The saline Dead Sea contains potash, bromine, and magnesium chloride.

One of the most outstanding characteristics of the Negev is its stark, natural beauty. The photographs here first appeared in Mr. Merom's recent book, *The Negev*, published in Tel Aviv by the Maariv Printing House.

BUTTERFLY, *Vanessa cardui*, rests on a bush at Ein Gedi, one of the desert's new settlements.

ACACIAS grow in the shadow of a hillside on Sinai border near Eilat, a Red Sea port city.



Invertebrate Learning

Octopuses prove receptive to complex training experiments

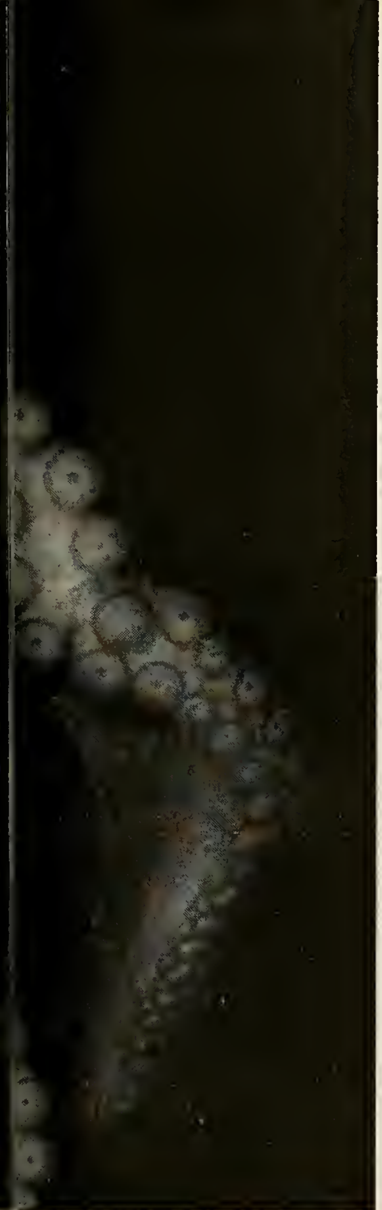
By Martin J. Wells

Colorful, graceful, and intelligent, *Octopus vulgaris* Lamarck is a beautiful animal. It will live well in a covered aquarium, given only a liberal supply of clean, well-aerated sea water, plenty to eat, and a heap of stones or bricks to create a "home" into which it can retire between explorations around its tank. Once it has settled down, the animal will spend most of its time sitting in the home, seeming to watch with interest everything that is happening in and around its tank.

Octopuses appear never to sleep. Anything that moves in the tank at once attracts an animal's attention. If it is smaller than the octopus, it will almost certainly be attacked; the animal emerges from its shelter to stalk the intruder, and finally leaps upon it, covering the prey with the web that joins the eight arms. The food is carried home to be eaten.

These animals have voracious appetites—a small octopus will double its weight in a month, if given the chance —and in aquariums they quickly be come tame. They even come out o their homes to "greet" people onc they have learned that, usually, peopl mean food. Their preferred diet i crabs, but they will also eat othe crustaceans, bivalves, and pieces c fish. Little octopuses are eaten by bi ones, and, in general, the animals ar antisocial, predatory, and better kep apart in individual tanks.

As experimental animals they are c great interest because of the ease wit which they can be taught to make



de range of visual, tactile, and taste criminations. If an octopus is given od as a reward when it grasps one of o objects that are exhibited sucsively at the far end of the tank, d a small electric shock (by means a probe, with which the animal can touched under water) when it asps the other, the animal learns in y a few trials to attack the one and nore the other. In this way, it can be ght to recognize figures of different apes—squares and circles, crosses l triangles—and to distinguish ong different sizes of the same pe. It can also learn, for example, distinguish between a square and a mond — the same shape rotated ough 45 degrees — or between the ne rectangle shown vertically and izontally. Octopuses make many h distinctions rapidly, within a tter of twenty or thirty trials (indiuals vary somewhat, as one might expect with any sample of intelligent animals taken from a wild population), and once having learned, remember for at least some weeks.

That the animals can so readily be taught opens up a number of possibilities. For one thing, it is possible to trace those parts of the nervous system that are concerned in learning by removing parts of the brain. Similar studies have, of course, been conducted on many kinds of vertebrate animals, and through the octopus work we are now beginning to be able to compare structure and function in the brains of cephalopods and vertebrates—two quite independent groups of animals—with results that should ultimately tell us much about the organization of both. Alternatively, by considering the problems that an octopus can and cannot solve, one can investigate some of the ways in which the animals classify the various objects they see or touch.

This second approach to brain function has formed the basis of a series of experiments conducted during the last few summers at the marine biological station in Naples. In these, octopuses, blinded by cutting the optic nerves, have been taught to distinguish by touch between objects they grasp with the suckers on the undersides of the eight arms. The initial purpose of the experiments was to provide a basis for brain lesion work on touch learning, by establishing some simple discriminations that the animals could carry out reliably before surgical interference with the central nervous system. But, as so often in research, the problem rapidly developed a series of sidelines that were interesting in their own right. One of these was the discovery of a distinct range of tactile discriminations that octopuses are apparently unable to make. These failures are particularly interesting in view of the many other tactile discriminations that are made without difficulty—not only because they tell something about the organization of the octopus itself but also because they reveal, by implication, a general truth about the organization of the nervous systems of invertebrate animals. It is the failures, their implications, and the experiments arising out of them that will be discussed in this article.

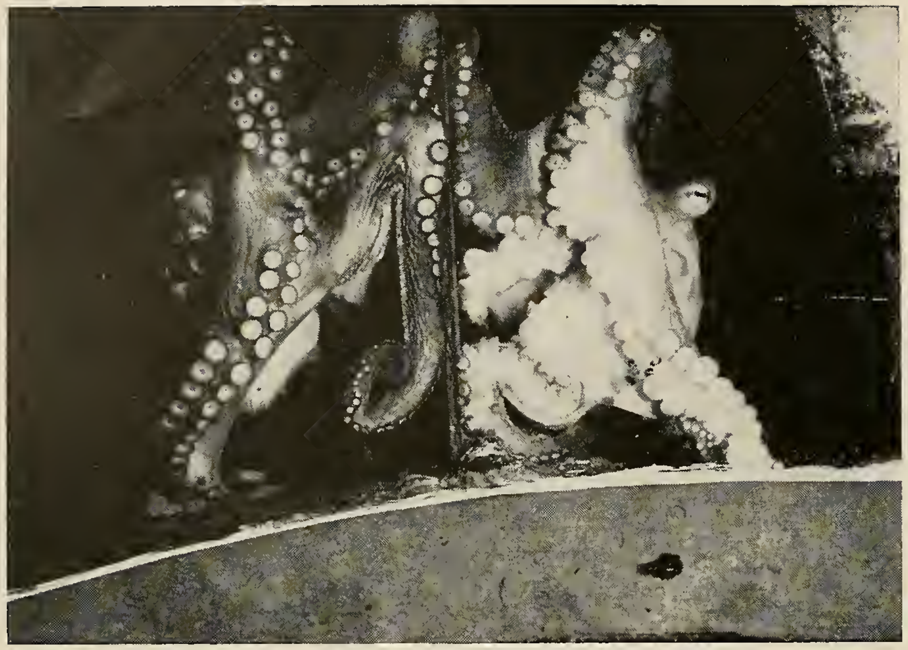
First, however, let us examine some of the tactile discriminations that octopuses can be trained to make. They can, for example, learn to discriminate among most of the cylinders shown on page 37. But (and here at once answers are found that at first seem curious by our standards) octopuses apparently make these discriminations entirely on a basis of the texture, or roughness, of the objects concerned. They do not, one finds, distinguish between cylinders such as A , B, and C that are alike in this respect, and they seem quite unable to detect that these equally rough objects differ in other ways. Differences in the orientation and/or the pattern of the grooves cut into the cylinders, which we can detect readily, apparently pass undetected by them.

Octopuses can also be taught to distinguish between cylinders of different size. But once again the results are a little odd by vertebrate standards. For instance, octopuses treat cylinders made of bundles of rods stuck together as being of the same size as their component rods, rather than in relation to their over-all diameter. The animal evidently classifies the cylinders on the basis of the distortion imposed on individual suckers, rather than on the degree to which its arms are bent around the objects.

As a check on this, octopuses trained to accept cylinders of large diameter and to reject small ones were offered a series of rough- and smooth-textured objects in a series of transfer tests; they accepted the smooth objects and rejected the rough. This implies that texture is equated with diameter, presumably because both are measured by the octopus in terms of the distortion of its suckers.

As with the textural discriminations already discussed, what happens at the level of the individual suckers seems to be all-important—size, like texture, is apparently determined from the degree of distortion caused by the contact. Indeed, it is arguable that size is a textural problem so far as octopus touch sense is concerned.

In addition to detecting some of the physical differences between the objects they touch, octopuses can distinguish tastes by using only the suckers. They can be trained to recognize and take or reject spongy objects soaked in solutions of such substances as quinine, sugar, or acids at dilutions well below the range of the most sensitive human tongue. In the wild, this



Alert octopuses watch photographer, instead of attending to the experiment.

Web spread and chromatophores around eyes extended, startled animal displays.

chemotactile sense is probably of the greatest importance in their search for food, much of which will be found hiding in crevices into which the octopus can reach but cannot see. At present, we know only that the sense is exceedingly acute and that the animal readily learns to distinguish among tastes under laboratory conditions; the range of distinguishable tastes, and the way the octopus classifies them, have so far not been investigated, largely because we ourselves find it difficult or impossible to classify such chemical stimuli.

Because octopuses can learn a great many distinctions rapidly, it was somewhat of a surprise to discover that there were certain categories of apparently simple discrimination that they never seemed to learn at all. Weight is one of these. Octopuses will pick up and handle heavy objects, but seem incapable of learning that they are more than usually hard to support.

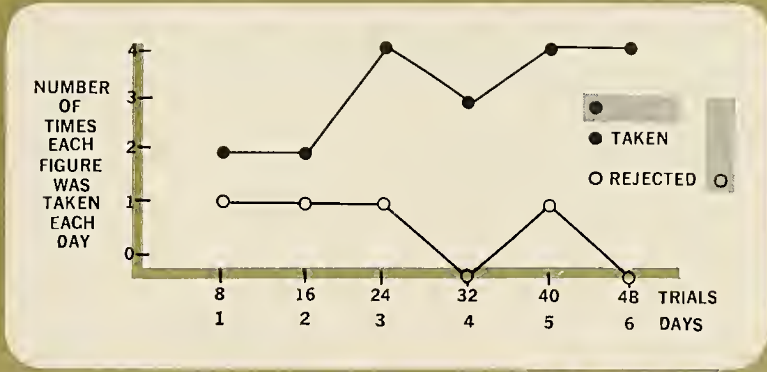
As a result, they never learn to distinguish between light and heavy objects in training experiments. They cannot be trained to pass one (say, the lighter) of two objects under the web to the mouth and to reject the other. Such results are the more curious because the animal makes obvious reflex responses to weight differences. An observer, watching an octopus being trained, can tell at once which of two objects, light or heavy, the animal is handling; the animal is muscular, and one can see the arm muscles tightening to take the strain. But the octopus itself never seems to remember the relationship between the force needed and the reward or punishment that follows when the object is passed under the interbrachial web to the mouth. Long training fails to improve performance, and the animals continue to respond at random for hundreds of trials, even when one of the objects is several times heavier than the other.

A further limitation of the animal's abilities is revealed when attempts are made to train it to distinguish by touch between objects of different shape. Training experiments show, for example, that octopuses cannot learn to recognize the difference between a cube and a sphere. although eventually, in most instances, they achieve a proportion of correct responses by treating the matter (once again) as a textural problem. We know that they make the identification by texture, rather than by shape, because of the way they behave in training experiments in which other shapes are presented. If an octopus that has learned (albeit after long training) to discriminate between a cube and a sphere is presented with a narrow rod, it almost invariably treats this as if it were the cube, taking or rejecting it without hesitation, just as if no change in the objects had been made. Indeed, for some of the animals the rod seems to be a "better" cube than the original; they make fewer mistakes in distinguishing it from the sphere. The implication—as in the size discrimination experiments—is that the distortion of the ten or twenty suckers in contact with the object is what is pertinent, rather than the over-all shape of the object grasped. A narrow rod can be regarded as a series of rounded corners; the cube has, in addition, large areas of flat surface. Because of this, the cube distorts only those suckers that happen to grasp its corners. The rod distorts all the suckers, and thus constitutes a sort of supercube, so far as the octopus is concerned, in contrast with the sphere, which cannot distort the circular rims of the suckers at all.

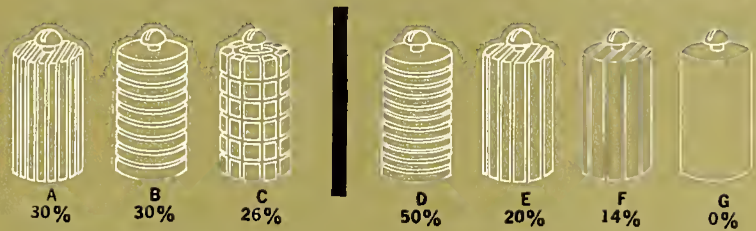
What have these various discrimination failures in common? Octopuses do not, it seems, distinguish the weights, the pattern of surface irregularities, or the shapes of the objects they touch. Presumably, these failures are related in some manner to the construction of the octopus central nervous system. Presumably, also, the difficulty does not arise from any failure of the animal's memory system (since octopuses learn other discriminations so readily), but rather from a lack of some relevant sensory input to the learning parts of the animal's brain. The problem is perhaps best envisioned by thinking first about ourselves. How would we solve the problems that an octopus finds impossible?

RY examining any small object, feeling it, without looking, to de- mine its shape. Consider the sources sensory information that you are ng. Finger-tip contact, certainly, also information about the move- nts of the fingers. Without knowing relative positions of the fingers l/or how these are moved over the face, it is quite impossible to deter- ne the shape of an object touched, size, or the pattern of any irregu- ties in its surface.

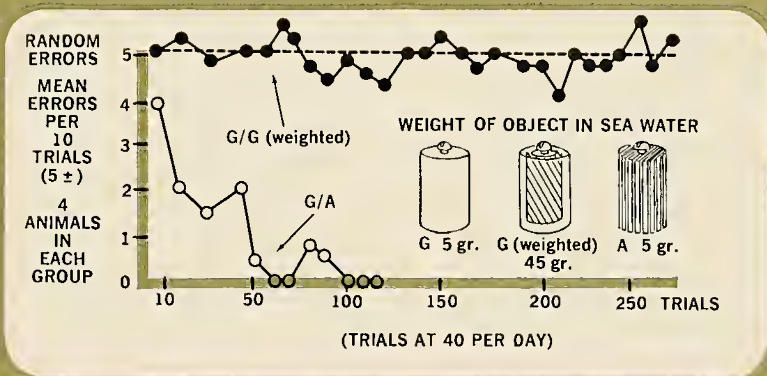
Vithout knowledge of the exact po- on of our fingers, we can find out y little except, perhaps, something ut the roughness or smoothness of things we touch; but even there discrimination is relatively poor. opuses can do better than we can ause their suckers are softer and e flexible than our fingers, and r sense organs are not overlaid by k layers of protective cells, as our ers are. As a result, they can deter- e very small differences in texture, since they are sensitive to taste ell, their tactile world has dimen- s we find difficult to imagine. o get some idea of the touch sense n octopus, one should perhaps try nining objects with the tongue. er than with the fingers. But with his sensitivity, the tactile world of octopus clearly lacks something is present in our own. The animal ns to have no equivalent to our er position sense. All the evidence



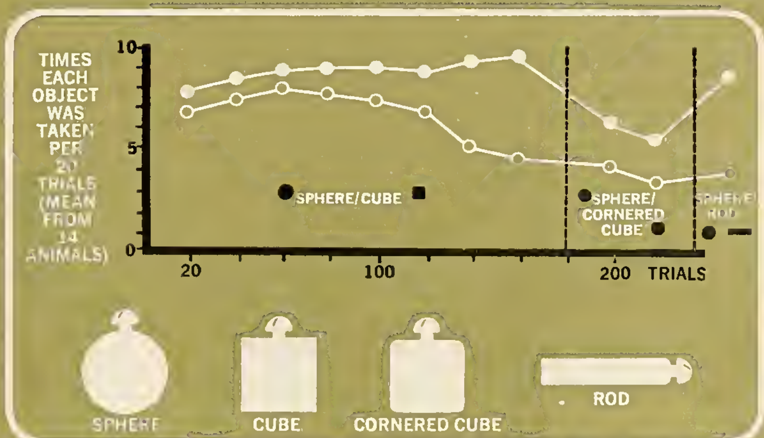
IN a visual training experiment, animal was rewarded for attacking a horizontal rectangle (solid dot) and punished for attacking the same one presented vertically (open dot). Graph shows increasing skill at test.



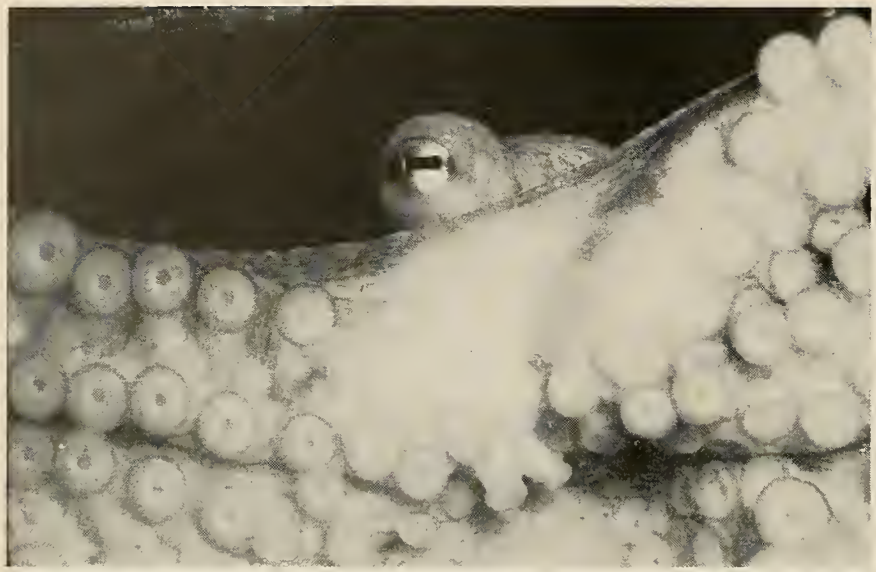
CYLINDERS were used to test learning by touch. Percentages show amount of surface cut away to form grooves as measure of roughness. Animals could learn to differentiate, except between A, B, and C, seen above left.



PLOTS of two tactile training tests show errors in every ten trials. Textural discrimination between A and G (above) was learned with ease. Discrimination between regular G and leaded G was not learned at all.



SHAPE TEST shows course of training for distinguishing between a cube and a sphere, and results of giving a round-cornered cube, then a rod, in place of cube. Positive and negative responses are plotted as in top graph.



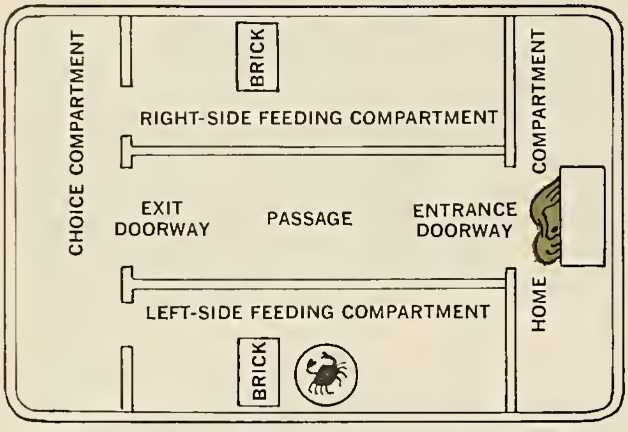
Undersides of arms are covered with circular suckers that can grasp small objects or rise at center to exert suction if applied to flat surfaces.

would suggest that it simply does not know where its individual suckers are, relative to one another, or how its arms are bent around objects.

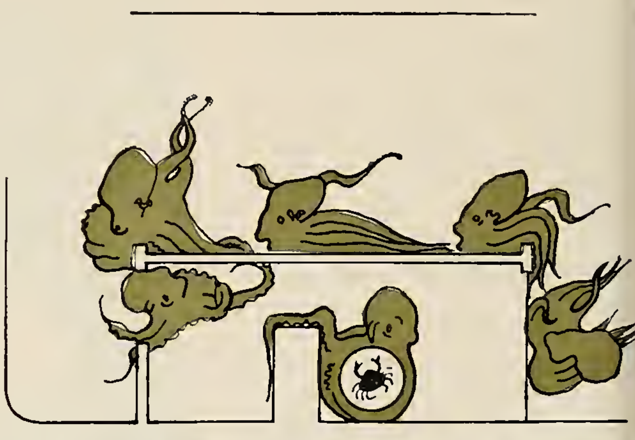
There are good reasons why this should be so. The octopus is a flexible animal. The movements of its limbs are not restricted by joints, and while this has many advantages from a locomotor point of view, it does set a major computing problem for the central nervous system. To know where my fingers are, my brain must take into account the bends at a couple of dozen different places; the problem is limited because I don't bend anywhere else. But for the unjointed octopus, it would require an elaborate computer, indeed, to assess the relative positions of eight arms, let alone the several hundred suckers, each itself mobile on a small, extensible stalk. The fact is, moreover, that soft-bodied invertebrate animals do not have unusually large brains—rather the reverse. Even an octopus has a small central nervous system by vertebrate standards, although its brain is relatively large compared with other invertebrates. The implication from this lack of brain is that such creatures—which include, for instance, all worms and mollusks—simply cannot compute the whereabouts of the ends of their flexible bodies in any considerable degree of detail. The very magnitude of the problem suggests that their motor control systems must, of necessity, be decentralized, with details of movements worked out by local reflexes, rather than in a central organization. In this event, the brain is required to order only the over-all pattern of movements, and because of this it probably never receives detailed in-formation about the position of the ends of its own body.

Similarly, the brains of many inv-tebrates never get precise informati about the effort needed to carry t their orders. An octopus—as we ha already seen—can lift a heavy objt when the brain orders it to do so. It the sensory feedback that records e degree of muscle tension required parently never penetrates to the hi-est centers, with the incidental rest that the animal can never learn to -tect weight differences.

A system that orders a response ad assumes that the details will look afr themselves may sound odd. Actua, even parts of human systems are o organized—our eyes are an examp. If we decide to look to one side, r brain orders contraction of the appr-priate eye muscles. The eyeball mov, and the image of the outside wod passes across the retina. The wod does not appear to move around s, because we know that we have mo d our eyes, and we take this into accoit in assessing what we see. We knw that we have moved our eyes, howev, not because we can feel the eyes mo, but because the brain has, as it we, filed a copy of the order with the -partments responsible for working it the significance of the retinal ima. If eye movement is blocked—by atta-ing a sucker to a contact lens on e eyeball and holding it, for instanc, this filed expectation is wrong. The is no movement of the image. But e brain has ordered a movement ad expects the image to move, so a -tionary image now implies moveme; the world sweeps past. People s-jected to this sort of experiment y



To get crab on other side of transparent wall, the octopus must traverse length of tank and make the correct turning.



Successful path of octopus, which loses sight of the p-y during trek, is shown as it appeared at 2-second interv-s.

that it is a most unpleasant sensation.

It seems probable that a great deal of the nervous system of soft-bodied animals is arranged in this manner—the activities of the various centers are integrated on a basis of copies of the orders to other parts of the nervous system, rather than on a sensory feedback from the motor machinery responsible for their execution.

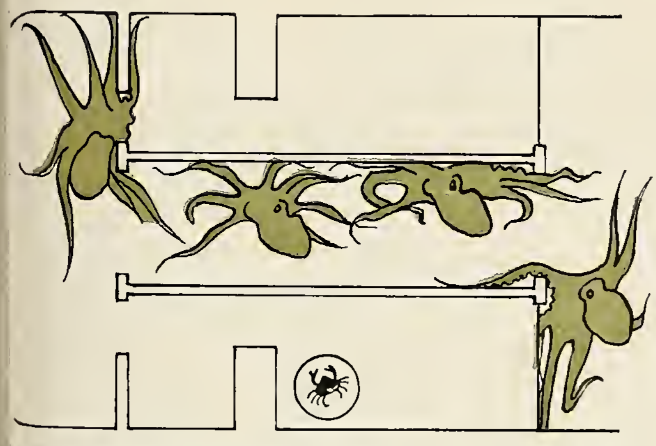
If this is so, the thinking and learning part of the octopus's brain can be regarded as related to the neuromuscular machinery that deals with the animal's movement rather as I am to my car. I turn the wheel and press the pedals. I have no direct feedback from the front wheels to tell me that my order has been carried out, and I have no direct information about the events within the brake cylinders or the control of the gasoline mixture in the carburator. I expect the details of the response to look after themselves.

Living machinery, fortunately, is a great deal more reliable than the machines we construct ourselves. It is not entirely unreasonable, therefore, for the thinking and learning part of the animal's brain to be organized on the assumption that its orders are always carried out, and for the animal to judge the effect of its orders from the consequent movement of the outside world, in much the same way as I judge the effect of turning the car wheel by the passing image of the external world that crosses my retinas. The octopus discrimination experiments yield results suggesting that this animal, at least, is organized with a brain that determines the broad outlines of movements to be carried out but has no part in, or knowledge of, organization of the necessary details.

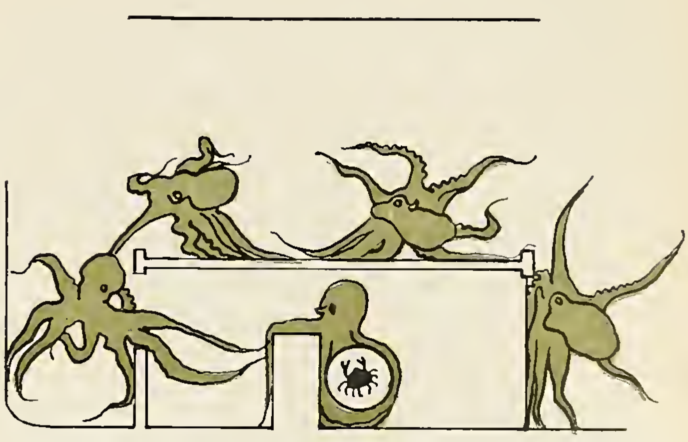
Blinded octopus sits on the side of tank with arms fully extended over the surface of the water. Most sense organs for touch are in suckers' rims.

The question is how to test the matter further. One way is to devise situations in which the animal's response to a sensory feedback will be different from the response to the afferent copy (a feedback in the central nervous system). The human eye example is one such test, and a related experiment can be done with the octopus—in this case to determine if the animal is aware of the position of its head and body as factors that will affect assessment of the retinal image.

For this experiment, the animal is first trained to discriminate by sight between two identical rectangles, one shown vertically, the other horizontally. It was found that the octopus, regardless of its position in the tank, continues to discriminate successfully between the rectangles. However, this apparently depends upon the eyes of the octopus remaining consistently oriented with response to gravity, so that the retinal image is itself constantly "right way up." Upset this "artificial horizon" and the animal ceases to distinguish between the rectangles. Experimentally, this can be achieved by removing the animal's balancing organs, the statocysts, which, among other things, produce the information that feeds reflex adjustment of eye position. After the operation, the slit pupil of the octopus no longer remains obstinately horizontal as the animal moves about; it varies, depending on how the animal happens to be sitting, and lies in the normal horizontal position only if the octopus sits squarely on the floor of its tank. When it sits on the side of its aquarium, the pupil (and therefore the retina) is at



Animal blinded in right eye enters the wrong corridor, fixes the wrong wall, and ends in the wrong feeding section.



Same animal detours successfully. Note how it kept to the correct wall, even though generally facing wrong direction.

right angles to its normal orientation. Under these conditions an octopus that has been trained to take the vertical rectangle before the operation will reach out and grab the horizontal rectangle, which it had previously learned to leave alone. It correspondingly avoids the vertical rectangle.

It seems that no matter how long training is continued, the octopus never comes to realize that it always gets the wrong answer when it is sitting on the side of its tank. The implication, once again, is that sensory information about bodily position never feeds back to the parts of the octopus brain concerned in learning.

The most recent confirmation of the view that octopuses cannot learn about their own movements comes from experiments in which the animals must make detours to reach crabs that they can see on the far side of a partition in their aquariums (*drawing, page 38*). To get the crab, the octopus must go into the corridor, out of sight of its prey, and trek round into the feeding compartment, making an appropriate left or right choice at the far end of the corridor. There are various ways the octopus could manage this. It might, for example, simply creep along the face of the intervening wall, or it could (assuming for the moment that sensory information about its movements does reach the brain) remember the turn it had to make on going into the corridor. It is found, however, that an octopus does neither of these things. It solves the problem visually, by fixing the appropriate wall with its leading eye as it goes into the corridor and hunting along for a break that will let it turn in the direction of the crab. We know this from the behavior of octopuses that have been blinded in one eye. After the operation, which in no wise interferes with their normal locomotion or their interest in crabs, the animals continue to detour successfully in one direction, but fail when required to collect crabs seen on the other side. They fail, it seems, because they go into the corridor and fix on the wrong wall; working along this one leads them into the wrong feeding compartment. They seem unable to learn to correct for this type of error.

The results with animals blinded in one eye are interesting because the errors are by no means inevitable. The octopus normally uses one eye at a time, anyway, and individuals blinded on one side do succeed from time to time in making perfectly satisfactory detours. One might expect them to learn by experience that getting food only follows their making a turn toward the wall when they go into the corridor. But instead they continue to make repeated unsuccessful runs 180 degrees off course, as in the example shown on page 39; on these occasions the octopuses detour quite as rapidly—one is tempted to say "confidently"—as usual, apparently unaware that an essential movement sequence is missing from their response. The implication, again, is that this animal is unable to take its own movements into account when it learns to carry out various activities.

The detour experiments, in short, confirm the thesis arising from t[illegible] tests on visual orientation and tact[illegible] discrimination. For these soft-bod[illegible] animals, learning on a basis of cl[illegible] from sense organs detecting exter[illegible] events is one thing, and possib[illegible] learning from internal receptors [illegible] quite another, and apparently not.

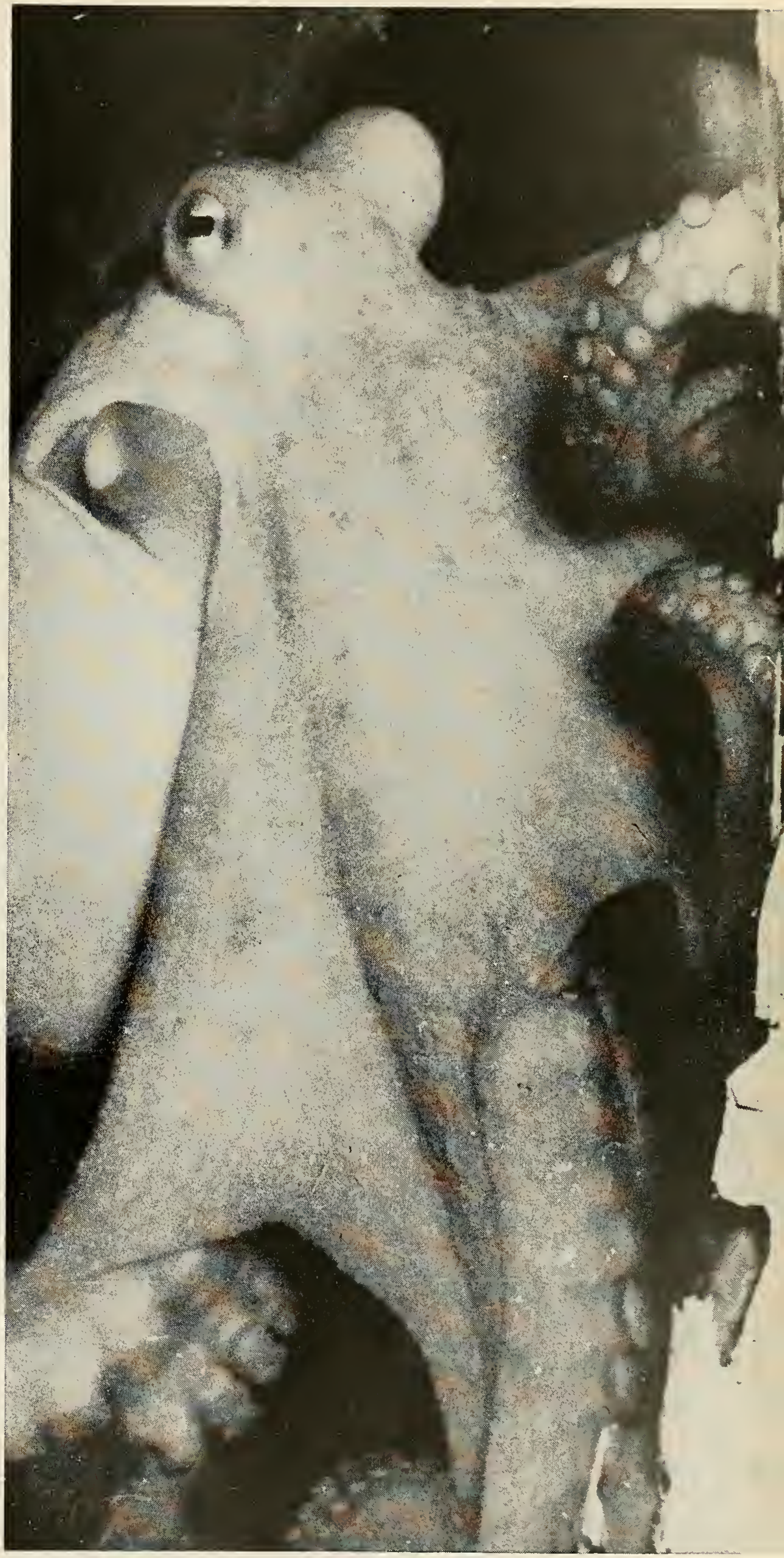
This conclusion has a variety [illegible] consequences for the study of anir[illegible] behavior. If true, it means, for a st[illegible] that there can be no question of a[illegible] mals such as octopuses learning [illegible] make skilled movements, since th[illegible] cannot learn to make progressive sm[illegible] modifications in the way they mani[illegible] late. All the motor machinery is the[illegible] but the sensory inputs that would [illegible] needed fail to penetrate to the up[illegible] levels of the central nervous syst[illegible] Operant conditioning, generally, p[illegible] sents difficulties. The means by wh[illegible] soft-bodied animals find their w[illegible] about become interesting because [illegible] must discard the possibility that [illegible] animal has anything in the nature [illegible] a map sense, based on the direct[illegible] and distance between objects in [illegible] environment. If an octopus (or a worm, or a limpet) has no memory [illegible] the detail of movements that it [illegible] made or been obliged to make on [illegible] outward journey, it cannot possi[illegible] compute its way "home" by any fo[illegible] of dead reckoning.

We are all used to the idea t[illegible] animals may differ in their capac[illegible] to learn. It would also appear obvi[illegible] that the range of things that they [illegible] learn is limited by the properties [illegible] their sense organs. It is perhaps a l[illegible] familiar idea to suggest that their p[illegible]

mance may be limited, not so much their sensory instrumentation as by way their central nervous systems organized to deal with the infor- :ion collected. The octopus is an mal in which the point is clear pre- ly because the animal learns to 'e so many problems so quickly; failures stand out against a wide kground of things that the animal be taught to do. The sensory instru- itation is there. The muscular ma- iery to carry out a variety of tasks resent. The animal's performance only be attributed to the organiza- al consequences of flexibility.

here is no reason to believe that octopus is exceptional in this re- t. It seems safe (or if not quite , at least interesting) to predict with increasing knowledge of the avior of animals, two broad cate- es will be revealed. There will be e animals, including humans and iaps the arthropods, that can learn odify their behavior by taking into unt details of the movements they e. And there are the rest—all the bodied animals, among which is octopus—that cannot.

T the present time we know more about the behavior of arthropods all the other invertebrate animals ogether. One reason is that arthro- can be made to perform well in ing experiments—maze tests and n—that seem simple to a verte- e. The other invertebrate animals 1 seem curiously dim by compari- and in most cases attention kly returns to the apparently more nising band of creatures with s. Work on the octopus has n, however, that soft-bodied, flex- invertebrates may be surprisingly k to learn, provided only that the riments are appropriate to their cular types of organization. One perhaps hope for equally interest- results elsewhere among the in- brates, as more sophisticated ods of testing their performances devised. It is the purpose of this le to call attention to one of the lexity of factors that must be 1 into account in such studies.



octopus reaches from heap of d shells to grasp yet more food.

PUPIL of eye remains horizontal atter how animal happens to sit.

By T. E. Eisner

Beetle's Spray

The rich and varied family Tenebrionidae includes a diversity of interesting forms that live in arid habitats. *Eleodes longicollis*, a large, flightless species about four centimeters long, is one of these. I first came across this striking animal in the desert country of our own Southwest, near the Chiricahua Mountains of Arizona. During the early hours of morning and again at sunset, the beetles may often be seen in large numbers, plodding about at a leisurely pace, their jet-black bodies clearly silhouetted against the pale desert soil. They are conspicuous even in the twilight, and the human eye soon learns to spot them from yards away. During the height of day, they are rarely present in the open. Like many other desert-dwellers, they avoid the scorching sun by hiding under rocks, beneath dung paddies, or in other secluded places. They feed throughout the night, at which time they may be found in a variety of bushes, clinging to the branches and chewing on the leaves.

While hiding in the daytime or while perched on shrubbery at night, the beetles are relatively safe from predators. But they face a multiplicity of hazards when they search for food or shelter along the desert floor. Dawn and dusk are the precise times when predation is at a peak in this habitat, and the ground then literally teems with ants, centipedes, spiders, scorpions, rodents, and many other potential assailants. How, one wonders, can a conspicuous animal like *Eleodes*, sluggish as it is, "afford" to take such risks? As we shall see, the paradox is only an apparent one, for *Eleodes* is really a highly invulnerable insect.

When *Eleodes* is disturbed, by being tapped with a stick or prodded with the fingers, for example, it makes no effort to flee. On the contrary, it usually comes to an abrupt halt and, in characteristic fashion, raises its rear and assumes a "headstand." This behavior has no defensive value per se, but it does signify that the beetle has been alerted to the emergency and is now prepared to counter the attack. The special weapon that it has available for this purpose becomes apparent the moment the disturbance is intensified. If, for example, the beetle is seized by hand or if one of its legs is pinched with forceps, it responds suddenly by ejecting an intensely odorous, golden-brown liquid from the tip of its abdomen. The vapors emanating from this discharge are highly irritating to the eyes, and the liquid itself, if it happens to penetrate open cuts or lacerations of the skin, causes noticeable pain. *Eleodes* is evidently endowed with an effective defense mechanism comparable to that of a skunk —or a whip scorpion (Natural History, June-July, 1962)—and it is this mechanism that accounts for its invulnerability.

Although initially one might think that the discharge consists of intestinal contents ejected by forcible defecation, one soon learns from dissection that this is not so. The fluid is a secretion, and the two glands that produce it are among the most conspicuous organs in the beetle's body. Each gland is a voluminous sac, ordinarily bulging with liquid and opening to the outside by way of a small slit adjacent to the anus. The cells that manufacture the secretion form an elaborate tissue that overlays the sac itself. No muscles surround the glands, and the mechanism whereby the secretion is expelled remains somewhat obscure. It is probable that the glands are squeezed by pressure generated indirectly, through muscular compression of the abdomen as a whole.

The secretion has the peculiar prop-

Discourages Predators

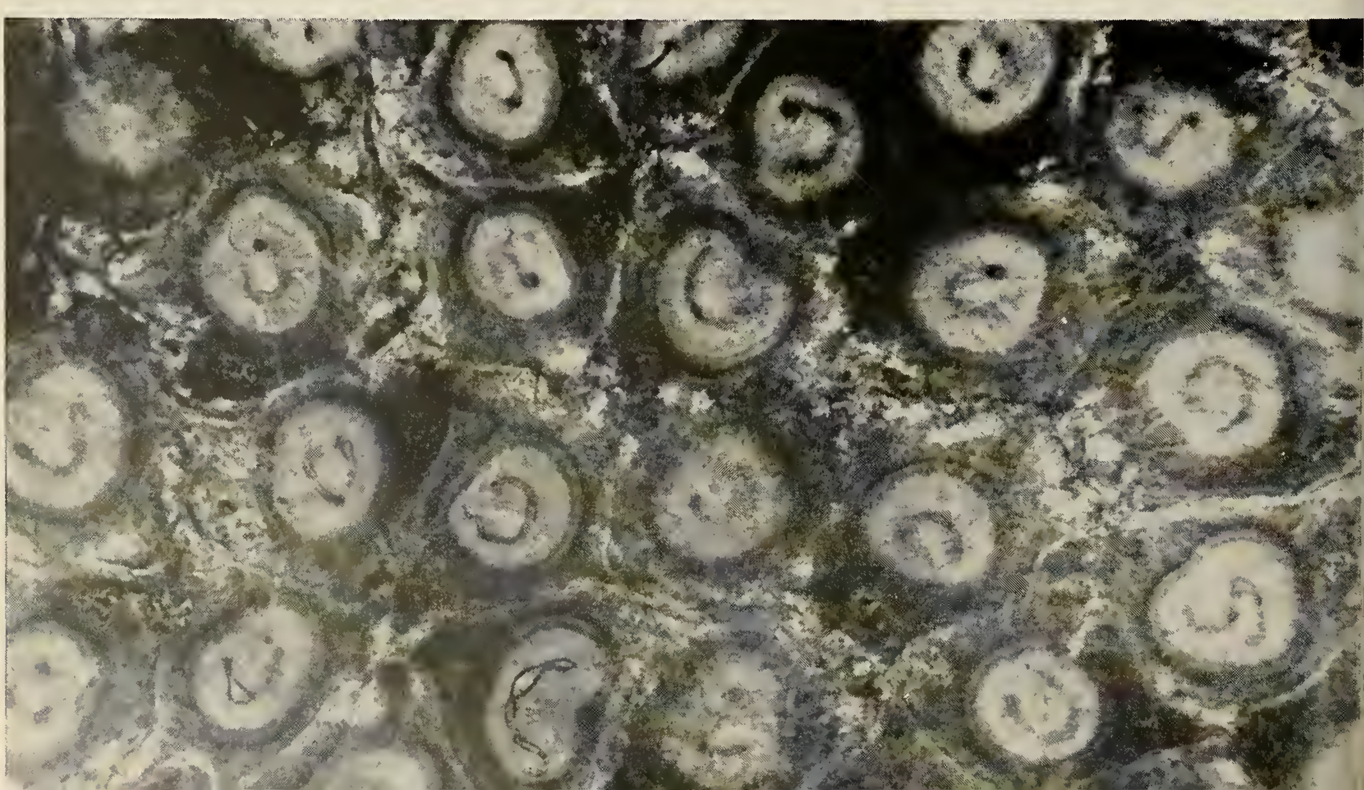
ONLY *Eleodes,* at left, has glands for defense, although *Megasida obliterata* also raises its rear whenever disturbed.

y of tanning human skin. This be- nes strikingly apparent after one spent an evening in the field col- ing the beetles by hand. Inevitably, 's fingers become stained an in- se purple, and the coloration per- s for days, until the skin wears off. number of arthropods besides *odes,* including among others cer- cockroaches, earwigs, and milli- ies, are known to produce secre- ns that stain the skin. In all cases ere these have been investigated, active principles responsible for ning have been shown to be certain tively simple organic compounds ed benzoquinones. This suggested possibility that the secretion of *odes* might also be quinonoid in ure, which turned out to be the case. Samples of secretion were obtained simply by holding individual beetles over an appropriate container, pinching their legs, and causing them to discharge into the receptacle.

MY colleague at Cornell University, Professor Jerrold Meinwald, together with several of his collaborators, did the necessary analyses. A picture on page 45 shows the three quinones produced by *Eleodes.* Although the secretion also contains other components, including several hydrocarbons and caprylic acid, the quinones are undoubtedly the chief defensive constituents of the mixture, since they are the ones primarily responsible for its irritant properties.

Experiments were carried out aimed at determining how repellent the quinones really are. One of these consisted of exposing predators of various types to the vapors emanating from pure quinone crystals. Ants, predaceous beetles, spiders, toads, lizards, and mice were among the species tested, and all of these showed some sort of avoidance reaction. Particularly dramatic were the results of still other tests in which the quinones themselves, either as crystals or in solutions, were applied directly to various portions of the bodies of these animals. The almost invariable response to such topical application was the performance of a most prompt and vigorous

BEETLE, *above*, responds to the pinching of one of its legs by discharging secretion into flask, *arrow*. The substance accumulates in the tubular organelles of the secretory cells magnified below, that overlay the animal's defensive gland



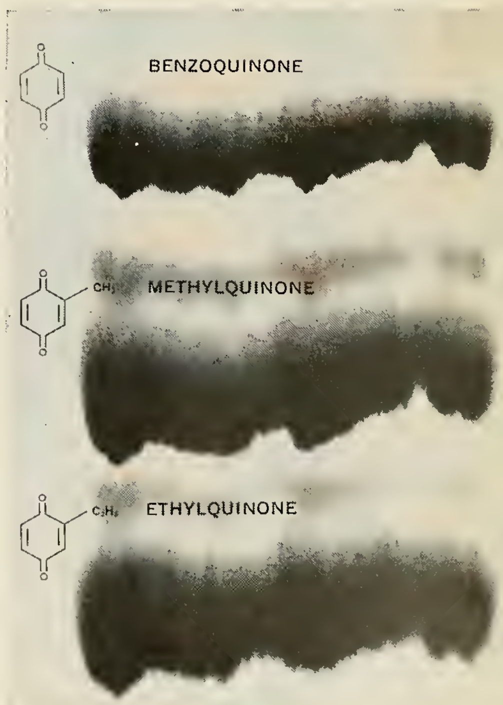
'o GLANDS, filled with brown liquid, are exposed in the
terior abdomen of a dissected individual, genus *Eleodes*.

ORIFICE, *arrow*, of *Eleodes longicollis* gland is opened by muscle (M) at moment of ejection. Cells (C) form tissues.

c insing reflex. Thus, when quinones e sprinkled on the back of a toad, t animal scratched itself with a leg. S ilarly, when they were applied to t mouthparts of ants and carabid b tles, the insects fled, dragging their n uthparts in the substrate. A mouse t t had its muzzle contaminated p ved it frantically with its front feet. E n such animals as lizards, which a shielded by an especially impervi- o integument, proved to be highly v nerable because of their sensitive e s and mouths. In short, not a sin- g predator tested seemed unaffected b quinones.

EVERTHELESS, it remained to be seen how effectively *Eleodes* u s its secretion in actual combat. To t end, individual beetles were of- f d to a variety of caged and appropriately aggressive predators, including many of the same ones that had previously been tested with the isolated quinones. With a single notable exception, which I will describe, the results conformed to expectation. When the predators attempted to seize, bite, or otherwise assail the beetles, they invariably received a retaliatory discharge and were forced to flee. As they escaped, they paused frequently to cleanse themselves, betraying obvious "annoyance" and responding precisely as they had to topical application of quinones.

It became clear during these tests that *Eleodes* does not eject its spray in a random direction. Just before dis-



CHROMATOGRAM shows how the *Eleodes* quinones separate in solvent on paper.

Tip of abdomen deflects downward as beetle effects headstand position and prepares to discharge. Spray leaves a purple stain on the researcher's fingers.

charge, the tip of the abdomen is always deflected downward, so that the secretion is expelled toward the underside of the animal in a slightly forward direction. This means that if the animal were to eject the spray while in its usual horizontal stance, it would create a puddle beneath itself, which would extend forward to about the middle pair of legs, but no farther. However, since it ordinarily discharges with its abdomen sharply raised, all six legs, and even the head itself, fall within the usual reach of the droplets. Thus, the headstand is to be viewed as an important preparatory maneuver that readies the beetle for the optimal employment of its weapon. This can be of real survival value to the animal, as field experiments with ants proved. In these tests, an individual *Eleodes* was placed near the nest entrance of a thriving colony of *Pogonomyrmex occidentalis.* Within seconds, dozens of the ants converged upon the beetle and, with their mandibles, clasped themselves tightly onto its legs and wherever else they could secure a hold. The beetle "froze" in its tracks, assumed the headstand, and sprayed. The ants dispersed instantly, and even those occasional ones that had grasped the beetle's antennae and mouthparts seemed to be spattered by droplets. They released their hold, and *Eleodes* was free to escape. The results of tests with caged toads were exceptional. The species selected, *Bufo cognatus*, is an especially large one, easily capable of capturing insects equal to *Eleodes* in size. As is well known, a toad catches its prey with its slimy tongue, which is flipped out and then retracted with the victim stuck to it. When an *Eleodes* was offered to *Bufo*, the toad caught it and gulped it down the moment the beetle came within range. This happened so quickly—a few seconds at most—that the beetle literally had no time to respond. If it sprayed at all, it must have done so after being swallowed. But even if this occurred, the secretion did not seem to cause any ill effects. The beetle was never regurgitated, nor did the toad ever refuse to eat *Eleodes* when these were offered on later days. Thus, although distinctly sensitive to the topical action of quinones, *Bufo* can cope with *Eleodes* for the simple reason that it can avoid having its skin sprayed in the process.

These laboratory findings may well be indicative of what actually happens in nature. In the vicinity of Portal, Arizona, where I studied *Eleodes*, there is also a toad, *Bufo alvarius*, that is even larger than *B. cognatus*. Examination of the stomach contents of several *B. alvarius* showed remains of *Eleodes* present in some of them.

There was also reason to belie that a predator of yet another sort w routinely preying on *Eleodes*. Wh searching for live beetles in the dese I occasionally came across the part remains of dead ones. These remai usually consisted of the front win (elytra), which in *Eleodes* (a fligl less insect) are fused to form a sin protective shield over the membrano back of the abdomen. The elyt shields found in the desert were ways damaged, and this in itself su gested that the beetles were victi of predation. Since the shields are sentially skeletal in nature, and co sist almost entirely of chitino cuticle, it seemed only logical that predator would discard them. I e amined them closely and found th their imperfections were consisten the same: the margins were typica jagged in appearance and seemed have been partially chewed away. appeared likely, although by no mea certain, that a rodent was the respo sible predator.

Appropriate traps, set out o night in an area where elyt remnants had been abundant, yield several individuals of *Onychom torridus*, a voracious nocturnal ins tivore known as a grasshopper mou The captives were taken to the labo tory and released in cages containi loose desert soil. In due course, aft they had adapted to their confin each was offered *Eleodes*. The eve that followed were spectacular. soon as a beetle was introduced, t mouse grabbed it and, while holdi it upright in its front feet, forced t beetle's rear into the soil. Undisturb by the beetle's discharges, which we being harmlessly expended in t sand, the mouse then ate its prey, b ginning with the head and proceedi backward, leaving only the legs, t elytral shield, and the tip of the a domen with the glands. At no tin during the entire procedure did t mouse incur the risk of bei sprayed; the beetle's rear was nev lifted from the soil. I later examin the elytral shield and found the antic pated jagged tooth marks. There r mained little doubt that *Onychom* was the predator I was after. It w not hard to explain why the elytr shields are usually found alone in t field, rather than with the other di carded parts. Being readily disperse by the wind, the shields are simp blown off by themselves.

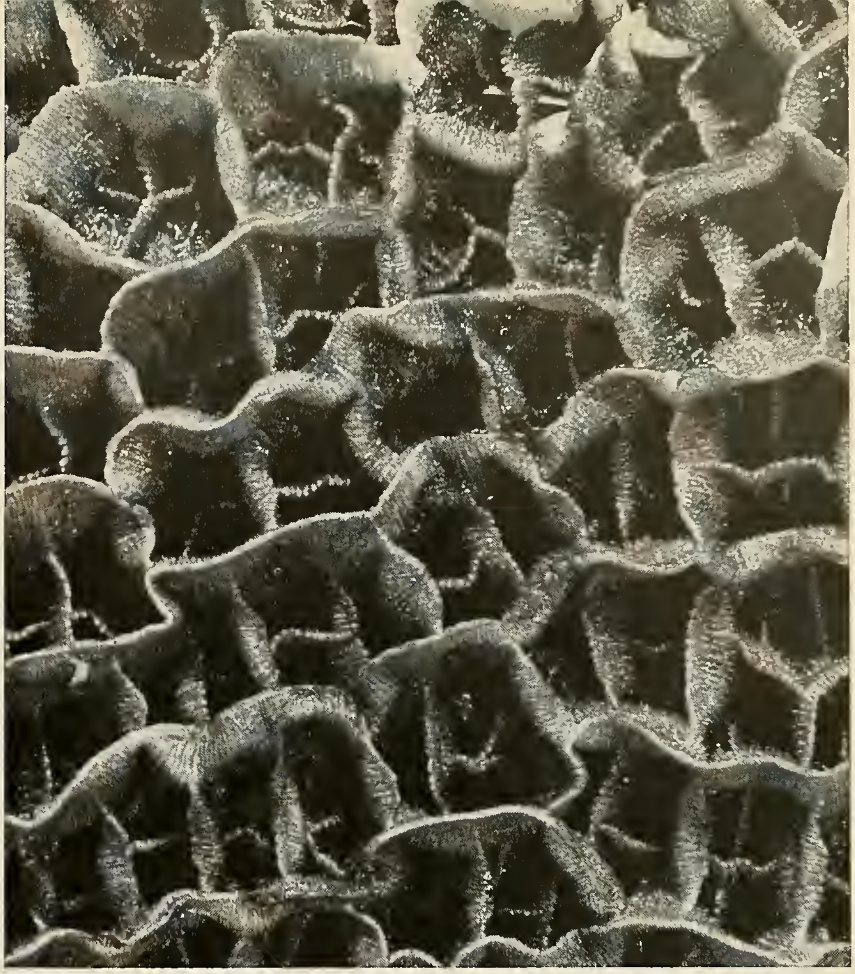
Together with *Eleodes longicollis*, rieties of other tenebrionid beetles o occur in the desert. Many of these black and flightless as well; they, , may be found pacing the desert or at dawn and dusk. Some are aller species of the genus *Eleodes* elf, but others belong to entirely ferent genera. Among the latter re is one, *Megasida obliterata*, that racts immediate attention because lso has the habit of coming to a halt h its rear lifted. Upon dissection, wever, this species was found to k glands. This was surprising, ce most tenebrionids do have quinone-producing glands like those of *Eleodes*. Could it be that *Megasida*, devoid as it is of its own chemical defenses, "attempts to pass" for *Eleodes* by mimicking the latter's headstand? It is certainly conceivable that some predators, having learned to identify *Eleodes* as an inedible species, will also discriminate against black beetles that resemble it, and particularly against those that raise their rears when disturbed. But which predators might these be? Rodents other than *Onychomys?* Or lizards? Evidently, there is still more to the *Eleodes* story than has been described here.

GNAWED elytra—fused front wings of *Eleodes*—were discarded by a predator.

GRASSHOPPER MOUSE holds prey so that harmful secretion is ejected into soil.

Fresh Viewpoints With a Camera

The impact of the most ordinary object, magnified, is sometimes startling, and in the resulting abstract quality can be found elements of a diverse and stimulating art. This can readily be seen in the dramatic pictures on these and the following two pages, all of which were taken by members of the Biological Photographic Association. These award-winning examples were on display at the Association's most recent annual convention, held in Philadelphia. The society was founded at Yale University in 1931 to further interest and research in photography related to the biological sciences. The membership consists of physicians, X-ray technicians, medical illustrators, and photographers. Some of the pictures in the exhibition represented a photographer's formal work, while others were admittedly the results of a busman's holiday with the microscope and camera.



PARASITE PORTRAIT

This picture of a louse, *left*, commonly found on marmots, was made by Don Fritts. A low-magnification microscope, with bright-field transillumination and contrast panchromatic film, was used.

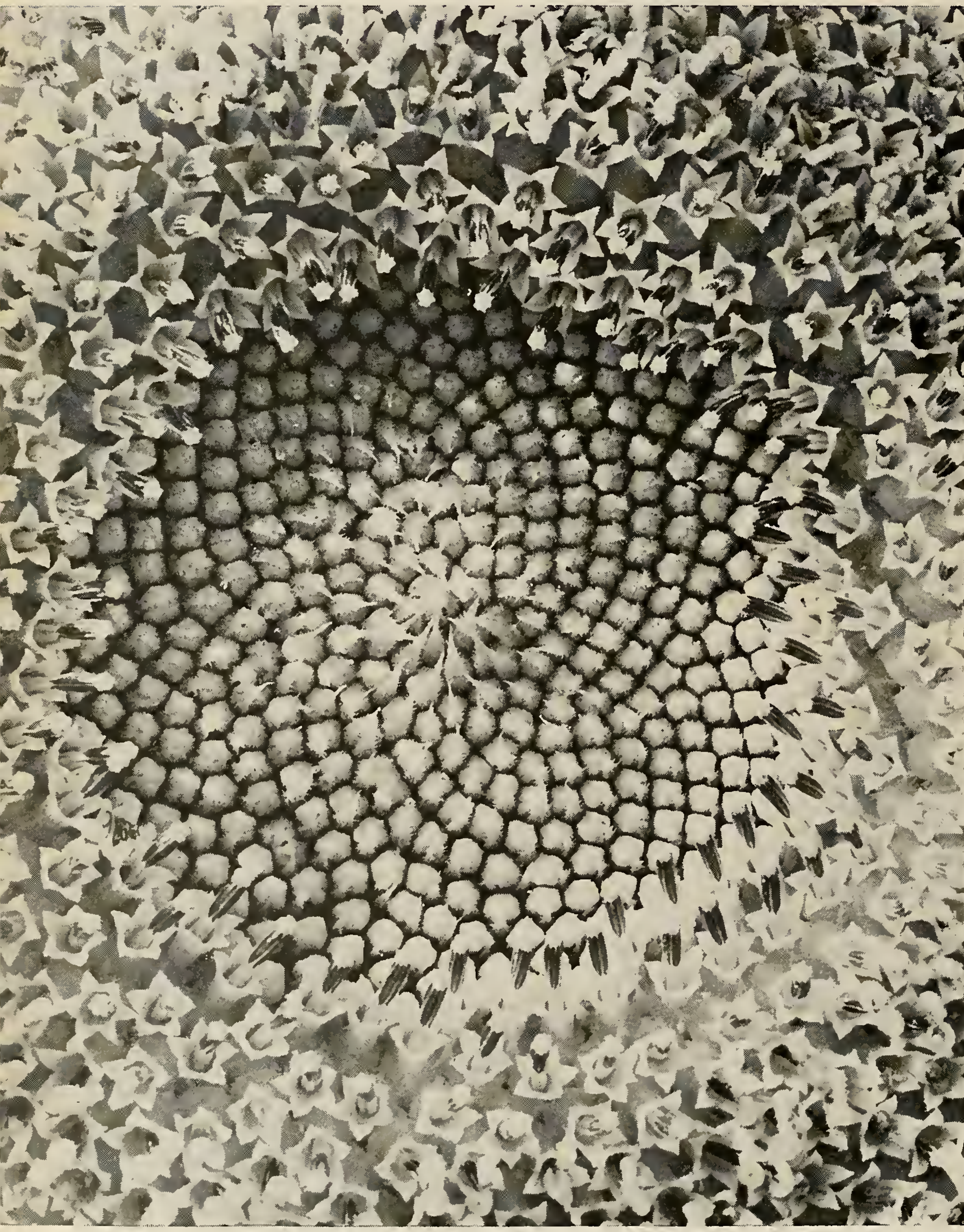
NORTH AMERICAN MOTH

Another award-winning photograph is shown below. It is of *Automeris io*, the Io moth, and was taken by Gordon W. Maxcy, who used an Exakta equipped with a Meyer-Optik Gorlitz f/2.8 lens.

HONEYCOMB

Photograph, *above*, also by Don Fritts, is of reticulum found in the anterior and smallest division of the bovine stomach. The photographer states that he took it because he "happened to like the design."

Hidden colors and contrasts

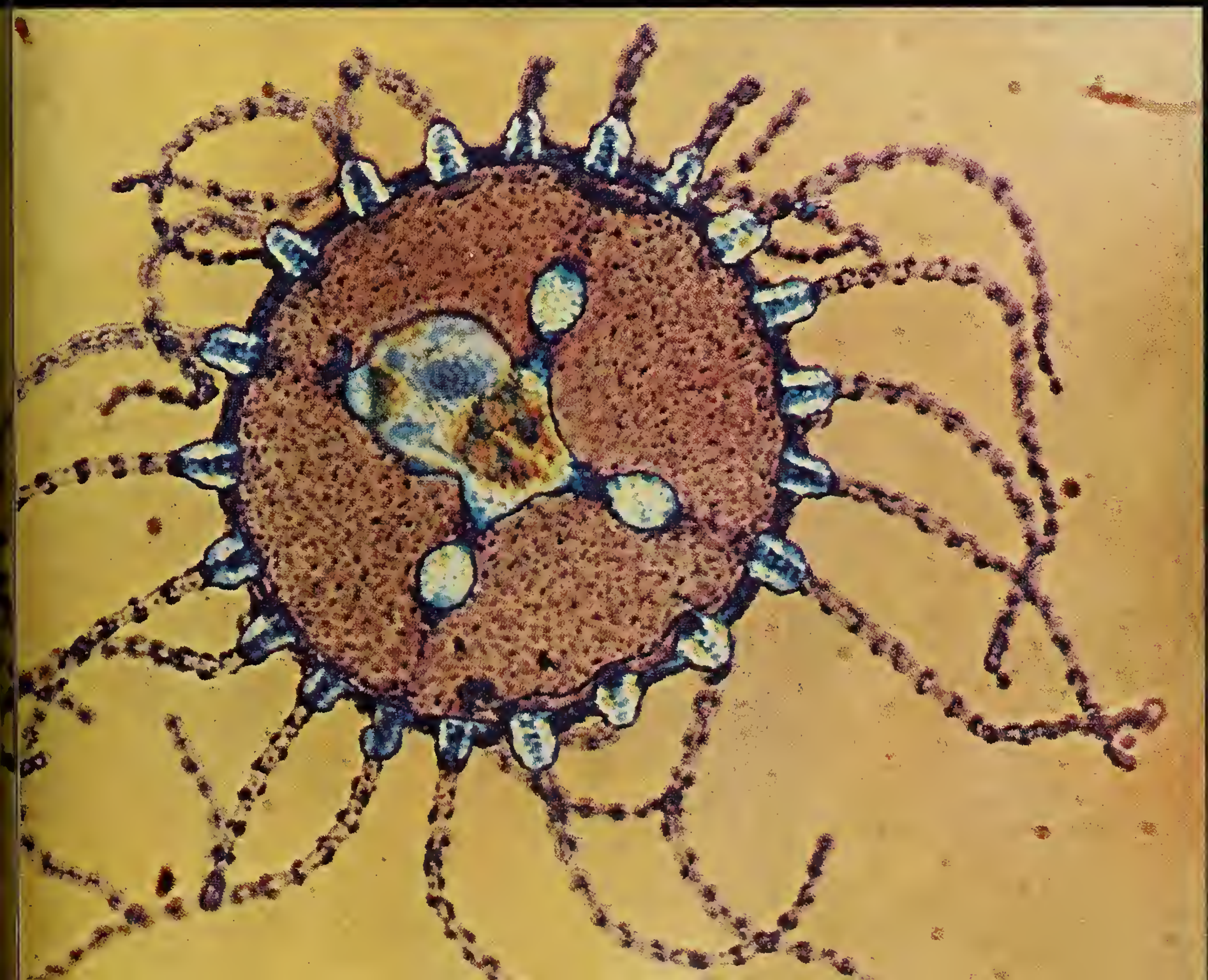


THE BEAUTY OF FLORETS AND SEPALS

As in all the Compositae, the florets are clustered in the center disc, surrounded in this case by the flower's yellow sepals. Sunflower photograph, one of a series, is by Hans S. Dommasch, of the staff of the University of Saskatchewan, Canada.

THE MAGIC OF THE INTERFERENCE MICROSCOPE

many living organisms are not colored, interference microscope translates to r minute differences in the optical erties of parts of the object under ervation. In the photomicrographs shown on this page, Robert F. Smith has employed this method to highlight many interesting details in his subjects. Centric diatom, *above left*, is a unicellular alga of a type that forms a large part of plankton. Carnivorous medusa of *Obelia*, *below*, a coelenterate, is shown waving its polyps. Photomicrograph, *above*, shows *Volvox*, a genus of green flagellates, which is ordinarily mistaken for common algae.



SKY REPORTER

ew, brilliant Ikeya-Seki is in amily of sun-grazing comets

By Thomas D. Nicholson

'HE first word about Comet Ikeya-Seki reached the astronomical community on a routine announcement rd from the Smithsonian Astrophysical Observatory, mbridge, Massachusetts, the clearinghouse in the United ites for astronomical discoveries. The S.A.O. also serves that capacity as an agency of the International Astro- mical Union. The I.A.U. Circular No. 1921, dated Sep- nber 20, 1965, stated that "Dr. H. Hirose, Tokyo Astro- mical Observatory, announces the discovery of a comet Ikeya and Seki." The discovery—the most spectacular net found so far in the twentieth century—was made lependently by two Japanese comet-hunting amateur ronomers on September 18, 1965. The announcement ve the magnitude of the comet at discovery as +8, and scribed it as "diffuse with a central condensation or cleus, and no tail." This description was confirmed by : Woomera, Australia, station of the S.A.O. There was le that was unusual about the discovery reported on cular No. 1921. Sometimes a dozen comets, never known fore, are reported annually on these cards. The only dif- ence in Ikeya-Seki was its extraordinary brightness.

Ikeya-Seki was the sixth newly discovered comet of the ır and was given the official designation of Comet 1965f. ter, after all 1965 comets have passed through perihelion, iew designation will be assigned to it (the year followed a Roman numeral to indicate the order of its date of ihelion passage among the comets of the year).

Although additional observations and preliminary orbits re reported on the next several I.A.U. circulars, these ports gave no hint that the comet was anything unusual. e surprise came on Circular No. 1925. After reporting eral precise positions for the comet, the card listed the ments of an accurate orbit based on these positions, and ephemeris describing what the comet would be doing er the next two weeks. The orbital elements indicated it the comet would pass closest to the sun on October 21, 65, at a distance that would place it at or near the actual face of the sun. The ephemeris indicated that the comet uld brighten to second magnitude as early as October 13 ight days before it reached perihelion. The orbital ele- nts and the ephemeris were enough in themselves to rt astronomers that Comet Ikeya-Seki was no ordinary e. According to the October 1, 1965, card, the orbit owed a "very close resemblance to that of the Great Sun- azing Comet of 1882 and its family," and it was esti- mated that the comet could be as bright as —7 when it reached perihelion. The card quoted Dr. L. E. Cunningham, of the Leuschner Observatory, who stated, "Brightness at this time [late September] is about the same as 1882 II under similar conditions. Observability will be the best possible for this sun-grazing group."

Interest in the so-called family of sun-grazing comets arose during the nineteenth century, when some of the most brilliant ones observed turned out to have almost iden- tical orbits, which brought them exceptionally close to the sun. These included Comets 1843 I, 1880 I, 1882 II, and 1887 I, which all developed very long tails and were ob- served principally in the southern sky. Two (1843 I and 1882 II) achieved the rare distinction of having been bright enough to be seen in daylight with the unaided eye. To the above four comets of the nineteenth century, sev- eral others have since been added, all sharing the same peculiar properties. The presently recognized members of the group include, in addition to the four named above, the comet of 1668, Comet 1945 VII, and Comet 1963 V (the latter discovered after it had passed around the sun).

THE orbits followed by the seven previously known mem- bers of the sun-grazing family are retrograde (they move round the sun opposite to the direction of the planets' motion). They are highly inclined to the plane of the solar system (they come from south of the solar system plane and return again to the south), and are of great eccen- tricity (they are long-period objects, with orbital periods of 700 to 1,000 years). Perihelion distances have brought them closer to the sun (almost grazing its surface) than any other objects known, and have produced the longest comet tails ever seen. The orbits of the sun-grazing comets also have one other outstanding characteristic: they are

INTING of sky, as seen by Dr. Franklin on October 21, 1965, ws elongated head of comet above and to right of sun.

Comet Ikeya-Seki was photographed just before dawn over San Francisco Bay area with a special, wide-angle camera.

ORBITS of comets like Ikeya-Seki are highly inclined and retrograde, coming from south of the solar system plane.

difficult to observe from the Northern Hemisphere, or—as was nearly the case with Comet 1963 V—they quite possibly can come and go undetected from any part of the earth.

With this as a background, Ikeya-Seki broke on the scene, apparently the eighth known member of the sungrazing family. By October 1, when it had already reached magnitude +6, it was still some 75,000,000 miles from the sun. Since it would come eventually to within 300,000 miles of the sun's surface on October 21, astronomers were confident that it would continue to brighten. Conservative estimates indicated it would reach magnitude —9 when it passed closest to the sun. This meant that it might be seen in the daytime sky (in comparison, Venus is visible in the daytime at magnitude —4, but far from the sun's immediate neighborhood).

ANY comet coming that close to the sun could be expected to develop an enormous tail. The tail of a comet results when gases from its head, vaporized by solar energy, are swept away from the comet by the pressure of solar radiation. Ikeya-Seki should be well cooked at its close approach to the sun and, in addition, should be subjected to great disruptive forces that could break it up or even destroy it totally. (After Comet 1882 II rounded the sun, its nucleus was seen to break up into five or six distinct parts.) On the basis of these factors, astronomers were justified in alerting the public to an object that gave promise of becoming the "best" comet of the twentieth century, even though they cautioned that comets, being highly unpredictable, do not always live up to expectations.

Public interest in Ikeya-Seki broke into a storm during the week of October 10. The American Museum-Hayden Planetarium, in New York, maintains an automatic telephone service to provide information about visible satellites and interesting celestial objects, answering calls with a recorded message. The service had been averaging slightly fewer than 100 calls per day. Within a week the volume rose to more than 1,000 calls per day, and it reached a peak of more than 2,400 accepted on October 21, when Ikeya-Seki rounded the sun. Hundreds of other que were received daily throughout this period on each of five normal business extensions into the Planetarium. Planetarium staff provided information, interviews, recorded programs for every major newspaper, news s ice, radio and television station in New York, and for m others far outside of the metropolitan area.

But throughout this wave of interest, it was almost possible to see the comet in the New York area, or f most of the eastern United States. Theoretically, up u October 16 or 17, it could have been seen without a scope in the early morning sky before sunrise. But e morning skies were persistently cloudy, hazy, or fo from early October up to the 21st, and the daytime sky the 20th and 21st contained high, thin clouds. Thousa perhaps millions, of persons looked and saw nothing.

The morning of October 21 promised the best sho all, for it was on that morning that the comet should h been visible in daylight. Our staff at the Planetarium made arrangements to fly over whatever cloud or fog c might obscure the sky from the ground. Dr. Kennet Franklin was to fly in a twin-engine aircraft with a pho rapher and a news commentator. Other staff members been invited to fly in a commercial jet aircraft in an e to see the comet. Although weather conditions were c to the allowed minimum, both planes managed to take

The jet flew to an elevation of 38,000 feet in an east of Long Island, but we could not see the comet, though we were well clear of any ground weather. Franklin, in the smaller plane, was 12,000 feet over vicinity of West Point, New York, and for at least minutes saw the comet clearly in daylight, well after sun had risen. The painting on page 52 shows the sk Dr. Franklin saw it, with the pale, white, slightly elong head of the comet above and a little to the right of the

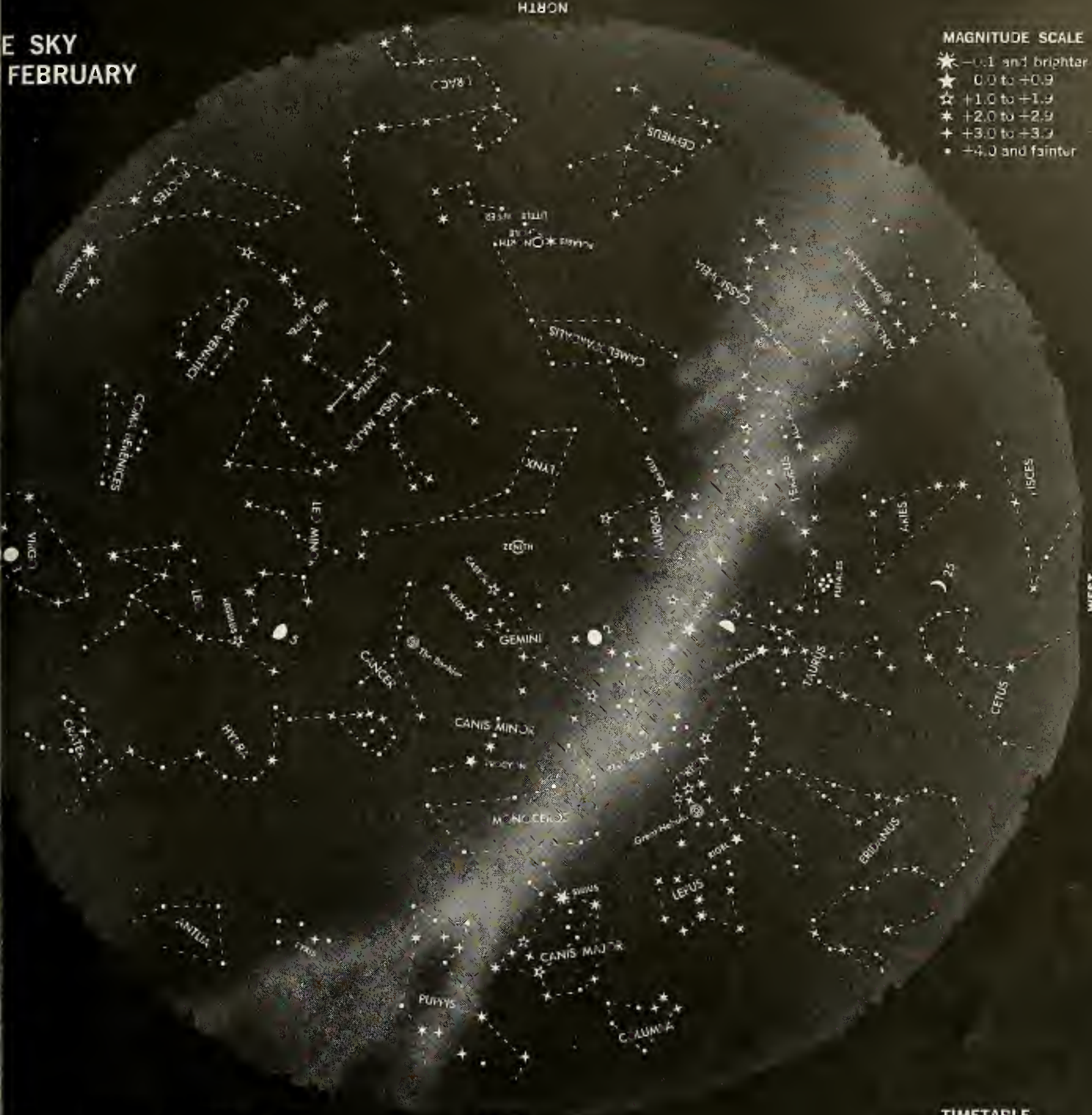
Dr. Franklin's observation, coming only seven h after Ikeya-Seki had passed through perihelion, was of the first to confirm that the comet had indeed bec bright enough to be seen in daylight and had survive close passage around the sun. Several days later the ci lars announced the result of other observations on the and estimates placed the comet's brightness at about ma tude —10 or —11, nearly as bright as the full moon.

After October 21, public interest in Ikeya-Seki wa By the 23rd, calls on the automatic dial service had f to near normal levels. Paradoxically, it was when gen interest had been all but lost that the comet began li up to expectations. The local weather changed for the ter. Each morning the comet rose earlier and appe higher in the sky as the twilight brightened—but it grew fainter. Beginning on October 28, and continuin more than a week, the morning skies over the New area were exceptionally clear, and Ikeya-Seki could be easily without optical aids. During this time, it grew a estimated to be about 45 million miles long, extending an arc of 20 degrees in our skies even though the c was about 100 million miles away.

Whenever a comet becomes bright enough to be se daylight and develops a 20-degree tail, 45 million long, we must grant that it is one of the rare come history. And we know that Ikeya-Seki did that. We sa

DR. NICHOLSON, the regular author of this column, is Chairman of the AMERICAN MUSEUM-HAYDEN PLANETARI

E SKY
FEBRUARY



Moon	February 5,	10:58 A.M., EST
Quarter	February 12,	3:53 A.M., EST
Moon	February 20,	5:49 A.M., EST
Quarter	February 28,	5:15 A.M., EST

TIMETABLE

February 1	11:00 P.M.
February 15	10:00 P.M.
February 28	9:00 P.M.

(Local Mean Time)

bruary 1: Jupiter and the gibbous moon are in conjunc- about 7:00 P.M., EST, the planet 2 degrees south of the n. Shortly after sunset, they appear high in the east, the n above Jupiter. Notice how the moon moves past Jupiter g the early evening hours.

bruary 5: About 5:00 P.M., EST, only six hours after it is the moon reaches perigee (the point in its orbit nearest). When the perigee moon and the full moon occur as as this, we may expect tides that sometimes have a 40 per cent greater than ordinary high and low tides. an expect exceptionally high tides tonight, and should east to northeast winds occur along the east coast on date, it is possible that flood conditions could exist along w-lying portions.

rcury enters the evening sky and is in superior conjunc- in line with the sun on the side opposite the earth.

ruary 15: Jupiter, as the earth moves away, is stationary ght ascension and resumes direct (eastward) motion gh the stars of the constellation Taurus.

Venus is stationary in right ascension in the morning sky and resumes direct (eastward) motion.

February 17: Venus and the late crescent moon both rise in the east before the sun. Conjunction is at 7:00 A.M., EST, when Venus is 12 degrees north of the moon.

February 21-24: A series of conjunctions occurs on these dates between the early crescent moon and Mars, Saturn, and Mercury, all of which are evening stars and close to one another. But they are so close to the setting sun that it is impossible to see them in the early twilight. On the 21st, the moon passes Mercury; Mars, and Saturn; on the 22nd, Mars passes 1.1 degrees north of Saturn; on the 23rd, Mercury passes 1.7 degrees north of Saturn; and on the 24th, Mercury passes 0.7 degrees north of Mars.

All Month: Only Jupiter (magnitude −2.0) is prominent in the evening sky, high in the east in early evening, and setting before sunrise. Venus becomes visible in the morning sky from midmonth on. Mercury, Mars, and Saturn are too close to the sun to be observed easily, even with the aid of a telescope.

About the Authors

After an early training in mechanical engineering, and ten years in industry working on problems of heat transfer and power generation, Dr. Carl Gans returned to Harvard University to receive his doctorate in biology in 1957. Author of "Locomotion Without Limbs," he is Associate Professor of Biology at the State University of New York at Buffalo and a Research Associate in The American Museum's Department of Herpetology. At present he is on sabbatical leave at the Zoological Laboratory, University of Leiden, the Netherlands, continuing his work on the functional morphology of vertebrates.

E. Javorsky, author and photographer of "Subtropic Flora Thrives on 50th Parallel," is a free-lance photographer and writer, temporarily associated with the Aquarium Publishing Company in New Jersey. His interests include gardening, architecture, painting, and general natural science subjects.

"Early Mapping of the Land and Sea" was written by Dr. George A. Rothrock, Associate Professor of History at the University of Alberta. He has studied in the United States and France, received his Ph.D. at the University of Minnesota, and has taught at the University of Omaha, the University of Michigan, and the University of Saskatchewan. He specializes in the political and social history of Europe in the sixteenth and seventeenth centuries, and is particularly interested in scientific and military history. He has written several books, and was author of "Steps to a New Astronomy" in the May, 1965, issue of Natural History.

Martin J. Wells, author of "Invertebrate Learning," is a graduate of Trinity College, Cambridge. He first began research on cephalopods in 1953 at the marine biological station in Naples, and returns there each summer to continue his studies. In 1956 he won a prize fellowship to Trinity. He is now a Lecturer in the University's Department of Zoology, and Tutor and Director of Studies in Zoology, Churchill College, Cambridge. In addition to many scientific articles, he has written two books, *Brain and Behaviour in Cephalopods* and *You, Me and the Animal World*. He lives four miles from Cambridge, and "keeps chickens, rooks, rabbits, terrapins, fish, a cat, and two small boys."

Dr. Thomas E. Eisner, author of "Beetle's Spray Discourages Predators," is Associate Professor of Biology at Cornell University. He specializes in insect physiology, and his writings on the subject have appeared several times in Natural History. His most recent article was "Mystery of a Millipede," March, 1965, coauthored with his father.

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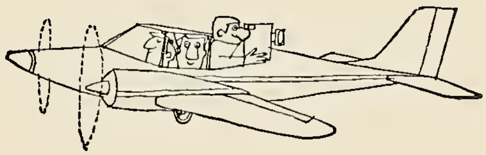

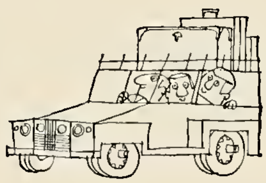

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continued from page 9

plays a dramatic "feel" for the subject, it presents the scientific results with truly scientific lucidity. The kind of verbal imagery that describes a moonrise also makes vividly clear the floral and faunal adaptations and specializations, the number and habits of species, the ecological factors, the dismal picture of wholesale wildlife extermination, and what can be done about it all. In the overall ecological investigation of the natural resources of Jordan's land and wildlife, a most sober analysis of the effects of human depredation upon such resources clearly comes forth. That this is paralleled in so many areas, including our own, strikes another blow for serious international concern for conservation. The summary of recommendations given in the final chapter might well have been given to the world at large, and not to Jordan alone.

Finally, the record of desert life encountered (216 bird species alone), the new species discovered and identified, and the superb photographic contributions of this book make it of lasting value. The inclusion of scientific and common species names provides the lay reader with a ready reference tool, and informs the professional, as well. Geographical notes, sociological description, scientific data, an appendix, and a selected bibliography are combined, by most capable writing, into a pleasantly instructive volume.

PHILIP C. HAMMOND
Princeton Theological Seminary

DANCES OF ANÁHUAC, by Gertrude Prokosch Kurath and Samuel Martí. *Aldine Publishing Company, $10.00; 251 pp., illus.*

THERE is probably no art more ephemeral than that of the dance—many of the most celebrated modern ballets were never recorded and have thus disappeared for all time. Gertrude Kurath has pioneered the use of a standard system of notation, called "Labanotation" after its inventor, Rudolph von Laban, to put down on paper the dance forms of the native peoples of North America, and she is justly famed for her researches.

The present book, however, trips lightly into a field where even angels would fear to tread. Just about all knowledge of the dances of the pre-Columbian peoples of Mexico and the Maya area (wrongly pooled under the term "Anáhuac") died with the Spanish Conquest. There are a few brief references to dance dramas among the Aztecs and Mayas in the post-Conquest chronicles, and even fewer pictorial representations of them in the same works, but these are flimsy evidence upon which to build a convincing picture of the Mesoamerican dance. Martí and Kurath have tried to extend this evidence by interpreting as dance movements anything in the repertory of pre-Columbian art that shows a person in an attitude other than a neutral stance. I, for one, am not convinced that most of these supposed dancers (such as the so-called Danzantes from Monte Alban) are dancing at all, and feel strongly that the matching of a particular figurine, usually taken out of context, with a passage in Labanotation has little or no meaning.

The number of factual errors and the mislabeling of illustrations pertaining to the pre-Conquest archeology and ethnohistory of Mesoamerica give little credence to the authors' reconstruction of native dance forms; I cannot believe that the three archeological authorities said to have checked the manuscript before publication actually did so. Given the scanty data upon which one has to work, an authoritative book on such a subject simply cannot be written.

MICHAEL D. COE
Yale University

PEOPLES OF AFRICA, edited by James L. Gibbs, Jr. *Holt, Rinehart and Winston, Inc., $10.50; 594 pp., illus.*

FIFTEEN culture profiles—succinct descriptions of the institutions, values, and physical surroundings of a human group—comprise *Peoples of Africa*. The editor has selected authors for their familiarity with peoples representing significant areas and ways of life. In order to afford the student an opportunity for further research, he includes those groups that have recently been studied in the field and that have previously served as subjects of a number of publications.

The societies described are the Kpelle of Liberia; the Afikpo Ibo, the Yoruba, the Tiv, the Hausa, and the Fulani of Nigeria; the Suku and the Mbuti of Leopoldville Congo; the Northern Somali; the Rwanda; the Ganda and the Jie of Uganda; the Tiriki of Kenya; the Swazi; and the !Kung Bushmen of the Kalahari Desert. Their institutions are comparable to those of many other African societies not mentioned in the text, thus providing a base from which a broader view can be projected.

Each article is divided into a more or less standardized set of categories, of which the more important are location, language, habitat and climate, settlement pattern, ethos (value system), economy, social organization, marriage, life cycle, political organization and law, religion, and change. Selective bibliographies conclude each chapter; most are annotated. The editor connects the articles by brief prefatory discussions.

In themselves, the articles are almost unexceptionable. When we consider, however, the stated primary objective of the book—to inform readers who

n no more than an introductory e in general anthropology—most of seem highly specialized in their nology and level of abstraction. e sections show a certain geographi- lustering and cultural overlap. Out teen articles, only three deal with les outside English-speaking Africa. ough probably unavoidable, at least mportant entities are omitted: the ating peoples of the vast Congo forest (of which neither the Suku he Mbuti are representative), and edentary, non-Islamic populations stern Sudan.

ere is a sprinkling of minor factual ypographical errors and of ambig- usages. The book's design is not ty of its content; it is a conventional ook—blocky in form, grayish, and nally illustrated. A good part of the seems superfluous or whimsical. ile the book should be valuable for ing and research (much of its ma- is published for the first time), it too important a source to be so d in its range of readers. Some re- , either by simplifying and stand- ing the terminology or by providing ninal glossary of scientific and Afri- sages, would probably accommo- he many who do not have the back- d necessary for the present edition. inclusion of additional sections— if two volumes were necessary— bring *Peoples of Africa* close to a tive treatment of its subject.

LEON SIROTO
Chicago Natural History Museum

ERFLIES AND MOTHS, by Alfred er and Josef Bijok. *The Viking , $10.95; 126 pp., illus.*

TTERFLY collectors are of three kinds, and so are books about but- s. Some collectors build up a com- collection of the species occurring given area—normally their own—or species of a certain family group, as the sphingids or the hesperids, xample. Other collectors need the flies as a basis for scientific studies biological, evolutionary, or zoogeo- ical nature. Together these col- s constitute the group known offi- as lepidopterists. They need , but books of a scientific character, as systematic monographs.

en there is a third kind of col- . Members of this group build up collections for only one reason— he result be something beautiful k at. Their primary concern, it be admitted, is not with system- ecology, or zoogeography; they re their butterflies solely for the re of looking at them and show- em to admiring friends. It is for persons that the present book has written and edited. After a short introduction of a somewhat strange literary character, dealing with such diverse persons as Plato, Martin Luther, Oliver Wendell Holmes, St. Thomas Aquinas, and Thomas Hobbes—none of whom has the slightest connection with butterflies—come the plates. This new edition has thirty-nine of them, all of outstanding quality and demonstrating just how well West German printers can do when at their best.

The original edition had forty-two plates, thirty-four of which represented mounted tropical butterflies. The last eight plates showed mounted specimens decoratively placed on flowers that do not occur in their habitats. The new edition drops the eight "adorning" plates, but adds five new ones, showing sixty-five species of European butterflies and moths. This seems to be a genuine improvement, although the accompanying text only covers the distribution as seen from the point of view of Great Britain. This is quite enough for a British edition, but an American collector would no doubt prefer to know something of the entire European distribution.

The book has practically no systematics value, but it is beautifully produced—among the best I have ever seen—and therefore is well worth placing on the butterfly bookshelf.

T. W. LANGER
Royal Library, Copenhagen

A CHEYENNE SKETCHBOOK, by Cohoe. Commentary by E. Adamson Hoebel and Karen Daniels Petersen. *University of Oklahoma Press, $5.95; 96 pp., illus.*

THIS delightful little book reproduces a collection of paintings by a Cheyenne Indian named Cohoe. In 1874, Cohoe was one of the Cheyenne terrorizing the southern plains. Forced to surrender in December of that year, Cohoe, along with other hostiles, was sent to prison at Fort Marion, Florida. Among the Plains Indians, men were accustomed to depicting their war exploits in paintings on buffalo hides. Shortly after arriving at the prison, some of the Indians began drawing on paper to pass the time and to earn a little pocket money. Cohoe's paintings are among the best produced by the captive Cheyenne.

After an introduction that gives a brief account of Cohoe's life, twelve of his paintings are reproduced in color. Accompanying each reproduction are a few pages of commentary on his artistic style and the ethnographic details in the paintings. The commentators skillfully use the art to give a sketch of Cheyenne culture and of Plains Indian culture in general. The quality of the color reproductions is good. The book is further illustrated with photographs.

STANLEY A. FREED
The American Museum

SCIENCE REPORTS

The vanished quagga

By David P. Willoughby

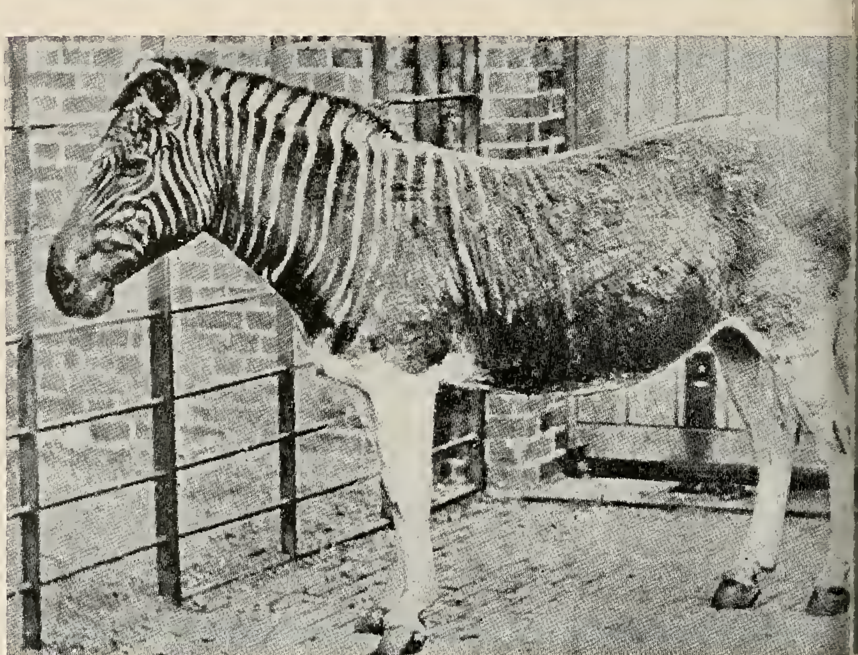
PARADOXICALLY, the more numerous and conspicuous an animal species becomes, the sooner it may disappear. A classic illustration is the Passenger Pigeon, which in the middle 1800's populated the middle and eastern United States in millions, yet was virtually extinct before the year 1900. The American bison, or buffalo, which now exists in only a few controlled herds, once swarmed over the prairies in numbers estimated up to sixty million. The pronghorn antelope probably was equally numerous. Fortunately, both these picturesque mammals were saved from extinction by legislation. In Africa, many splendid game animals have experienced a similar decimation. The springbok, a beautiful antelope now seen only in small groups, was described by early travelers as migrating in immense *trekbokens* containing from ten thousand to fifty thousand individuals.

The quagga probably never existed in such large numbers, but its relatively sudden disappearance from its age-old homeland, the veld, constitutes a sad but enlightening instance of what may happen when human foresight is nonexistent. The quagga was a handsome, zebra-like animal, with stripes that, as a rule, covered only the head, neck, shoulders, and part of the trunk. The hind half of the body and the legs were free of markings in most individuals. The usual ground color of the striped parts was yellowish red or chestnut. From the back down, this color gradually faded, becoming pale fawn or white on the belly, legs, and tail. Along the middle of the back was a broad, dark stripe. The mane was dark brown with fawn bands, although in mounted specimens the fawn color faded to white and the mane lost its "trimmed" appearance.

Zoologically, the quagga was allied to the group of African striped equines known as Burchell's zebras, named after the British explorer-naturalist of that name. In addition to the quagga, the group comprises one extinct and three living subspecies and some twenty described local forms. The extinct race, known as the true Burchell's zebra, was without striping on the legs and lower parts of the body. It was to this subspecies that the quagga was most closely related geographically and in coat pattern, although it was quite different in body size; the true Burchell's zebra was considerably larger. Also, there were minor anatomical differences between the quagga and the living Burchell's zebras (*Equus burchelli*), which are most closely related structurally.

Identification Problems

THE Burchell's zebras—to distinguish them from the true, or Cape, Quagga—were called *bontequagga* by the Dutch; the word means "painted, or conspicuously striped, quagga." This



Photographed in London in 1870, this is among last of quaggas

of quagga in the names of both ani-
s is unfortunate, and has resulted in
h confusion between the two species
en by certain zoologists, who as-
ed that the true quagga was merely
lor variant of the *bontequagga*. The
e quagga, incidentally, comes from
Hottentot word *quahkah*, and refers
he animal's barking cry. Evidently
cry, or neigh, was identical with
of Burchell's zebra. By the Boers
as pronounced *kway-hay*, the last
ible being much prolonged.

he true quagga never had a wide
ge. During its period of greatest
ndance historically, it was found
the central plains of Cape Hope
nd over the vast veld of the Orange
State. Its northern limit was prob-
the Vaal River; its western limit a
running from the mouth of the Vaal
r to the vicinity of Swellendam; its
hern limit the shoreline of Cape
ny; and its eastern limit the Kei
r. It was exterminated in Cape Col-
sometime between 1865 and 1870.
possible that a few individuals sur-
l in the Orange Free State until
, although some writers give the
year as 1873.

ne first mention of the quagga in
ern times seems to have been made
. Tachard in 1685. He called the
nal "wilde esel" (wild ass), but de-
ed it in such fanciful terms that his
unt is useless for zoological purposes.
first scientific mention of the quagga
probably that made by George Ed-
ls, who in his book *Gleanings of
ural History* (London, 1758) showed
or plate of a quagga mare, which he
neously supposed to be the female of
nountain zebra—an entirely different
of zebra, by the way. A few years
, the first authentic, detailed account
ne quagga was published by a Dr.
mand from notes received from
nel Gordon of South Africa. This
unt was reprinted by the celebrated
ch naturalist Buffon in 1782. About
, a Dr. Sparrman corrected Ed-
s' idea that the quagga was the
le mountain zebra. He went on to
urther, in his book of travels, that
quagga was highly valued by the
nists because it would protect their
from the attacks of wild dogs and
as. On this point the British natu-
Graham Renshaw comments: "If
old stories are true, the quagga
ed a high degree of courage in fac-
nimals [Cape hunting dogs] able
nquer the lion. Bay horses, however,
noted usually for their spirit, and
int entered largely into the colora-
of the quagga!"

e quagga seemed to prefer the com-
of black wildebeests (white-tailed
), ostriches, and sometimes harte-
s. In this respect it differed from
Burchell's zebras, which associated

habitually with the brindled gnu, or ie wildebeest. Moreover, it is said that ie quaggas did not mingle with the h ds of Burchell's zebras, but remainec in separate groups.

Decline of a Species

MANY travelers over the veld du ig the period 1773-1820, and s ie even a decade or two later, found ie quagga in vast numbers. William J in Burchell, writing in the year 1812 al the herds of quaggas then on the v d, remarked: "I could compare it [the it-ter of their hoofs] to nothing but to ie din of a tremendous charge of cavalry or to the rushing of a mighty tempes I could not estimate the accumulated n n-ber at less than fifteen thousand, a g at extent of the country being actu ly chequered black and white with t ir congregated masses. As the panic ca d by the report of our rifles exten d, clouds of dust hovered over them, d the long necks of troops of ostri es were also to be seen, towering above ie heads of their less gigantic neighbo s, and sailing past with astonishing ra d-ity. Groups of purple sassaybes id brilliant red and yellow hartebeests le-wise lent aid to complete the pict e, which must have been seen to be p p-erly understood, and which beggars ll attempt at description."

But alas, the picture painted th words by Burchell is one that will n er be seen again, for within the half cen ry following his description the once st herds of quaggas were reduced to a w lone individuals. The main cause of is zoological tragedy was the huntin of the quagga by Boer farmers, who d the meat to feed their Hottentot wor s, but who themselves preferred more l-atable game. The hides were made to sacks for the storing of grain, d d fruits, and dried meat, although wa n-loads of them were also taken to ie coast and shipped abroad.

While the exact date of the final e n-mination of the quagga in the wild s te is unknown, owing in part to the n-fusion by many observers of this spe es with Burchell's zebra, it may be se as probably not later than 1879. The st known quagga in captivity died in 1 3.

The Last of the Quaggas

IN the early 1800's and even be e, quaggas were occasionally tamed id shipped alive to various zoological r-dens in Europe. In a number of insta e-they were broken to harness, and t re is a record of two young adult m es being driven in Hyde Park, Londor by a Mr. Sheriff Parkins in 1826. A in, about 1860, a team of quaggas was ed in Regent's Park for drawing a w on that supplied food for the other ani ls in the zoo. A drawing by Edwards le-picted one of the first specimens o h

R. WILLOUGHBY is currently engaged publishing the results of thirteen ars of research on the genus *Equus*.

gga to reach Europe alive, although he plate, made in 1751, some of the ures and bodily proportions were irdly exaggerated. This particular nal was the property of the Prince Vales.

wo of the most interesting specimens iving quaggas were the male and female that once lived contempora- isly in the Regent's Park Zoo in don. As there has been much con- on attending the identities of these —among the last living specimens heir race—I should like to clear up e of the errors involving dates, ani- s, and final disposition of skins and etons. In 1858, Sir George Grey pre- ed a male quagga to the Zoological iety of London. This animal lived in ent's Park until June, 1864. Its skele- is in the British Museum (Natural ory), as is also the mounted skin.

he second Regent's Park quagga was emale purchased by the Zoological ety on March 15, 1851, which died uly 7, 1872. It was noteworthy be- se it was one of the only specimens ographed in life, two different pic- s having been taken in the summer 870 by Mr. F. York. The only other ure of this quagga was taken by r. Frank Haes. After death, the skin nis animal—said to be in "bad" con- on—was lost. The skeleton, however, preserved, although no one, evi- ly, knew where it was until I "redis- red" it in March, 1952.

seems that after the animal died, 872, the body was sold to a London lermist named Edward Gerrard. rard disposed of the skin, but pre- d the skeleton for mounting. In a r dated April 14, 1873, sent to the rican paleontologist O. C. Marsh, ard offered the quagga skeleton for This offer was promptly accepted Iarsh, who presented the skeleton to Peabody Museum of Natural History Yale University. I measured this eton, including the skull, in 1952, ugh the courtesy of the former Cura- at Peabody Museum, Dr. Joseph T. gory. Since the skeleton was of an female quagga, which was known ave been purchased by Professor sh from Edward Gerrard, it solves mystery of the missing female gga photographed by York.

ne last living quagga was another le that lived in the zoological garden msterdam from May 5, 1867, to ust 12, 1883. Its skull and mounted are in the Amsterdam Museum. other quagga survived the London le; this, too, was a female, and it kept in the Berlin Zoo until 1875.

SCIENCE IN ACTION

Choosing a site to dig

By Shirley Gorenstein

ARCHEOLOGICAL sites, unlike mountains, are not dug "because they are there." Rather, an archeologist chooses a site because he is interested in particular cultural or historical problems and hopes to find information that will solve them. One of my interests, for example, is in military organization in central Mexico during pre-Columbian times. After several years of research, I had concluded that while the military pattern in Peru appeared to be specialized—with standing armies and special military buildings, such as fortresses—the Mexican pattern was unspecialized—with militias and supplementary military constructions, such as protective walls around towns. To gain further information. I wanted to dig an Aztec period site with military features.

But before an archeologist can dig a site, he must find it. This usually involves both library research and a preliminary field investigation. or site survey. and may lead either to the reappraisal of known sites or the discovery of new ones, depending on what the archeologist is looking for. In the summer of 1964 I made such a survey in central Mexico.

Initial Research

MOST of our knowledge about Aztec culture comes from sixteenth-century Spanish writings, and among the documents that I found especially useful were letters from Hernan Cortes to his king, Charles V, and an account titled *The True History of the Conquest of New Spain*, by Bernal Diaz del Castillo, an officer in Cortes' army. Cortes and Diaz, both professional soldiers, were quick to note the military features of towns they encountered. Also helpful to my research were the sixteenth-century lists of Mexican towns compiled by both Aztecs and Spaniards. Some of the lists contain descriptions that help indicate which towns had military features.

There were not many archeological references in the documents. however. Little work had been done specifically on military sites, and for the most part I was able to find only brief reports. Two articles by the noted Mexican archeologist Pedro Armillas—"Meso-American Fortifications" and "Fortalezas Mexicanas"—were extremely helpful. Another valuable source was *Atlas Arqueologico de la Republica Mexicana*, which lists many of the known archeological sites throughout Mexico.

After going through the literature available in both English and Spanish, I decided to investigate six sites. Be[-] cause they are within about one [hun-] dred miles of each other, all six cou[ld be] covered in two weeks.

Locating the Sites

THE first step was to attemp[t to] identify the probable location o[f the] ancient towns mentioned in histo[rical] sources. Modern editors of the [ear-] Spanish literature are helpful, as [they] often try to determine the current [name] of a town mentioned by the Span[iards] or to locate the town on a map. In [addi-] tion to noting these exact location[s on] a large-scale map, I also marked [the] suggested locations of ancient t[owns] that lack present-day counterpart[s. If] a particular townsite had already [been] identified by an archeologist. it [was,] of course. relatively easy to find [on the] map. The directions are somet[imes] vague, however, and I often had to se[arch] for the localities in the field.

In Mexico City, archeologists o[f the] Instituto Nacional de Anthropo[logia] e Historia gave me directions to the [mod-] ern towns associated with the sites [and,] where they could, specific direc[tions] to the sites themselves. With this i[nfor-] mation and an up-to-date book of [road] maps. I set out in a small car, ta[king] with me a field pack that held measu[ring] tapes, a compass, notebooks, a 35 [mm.] camera with normal and wide-a[ngle] lenses. and enough film for about [a few] hundred pictures.

The first place I investigated [was] Huexotla, about twenty miles ea[st of] Mexico City. Although not well k[nown] to tourists, the site was partially [ex-] cavated and restored by Mexica[n ar-] cheologists a number of years ago. [The] ruins are all within an area about [one] mile long and one-third mile wide, i[nter-] spersed among the houses and fiel[ds of] present-day farmers. There are s[even] major structures at the site: t[hree] pyramids, the walls of two building[s, an] "observatory." and also a great [wall.] One of the pyramids had been cle[ared,] and its severe lines and gray color s[tand] out against a background of low, g[reen] trees. A ramp, interrupted by two s[teps] in the center, leads to the flat top o[f the] pyramid. where a plaster floor [still] shows traces of red pigment. From [here] one can see and be seen across the [...]

DR. GORENSTEIN teaches at Columbi[a] and directs field work in Mexico. S[he] wrote *Introduction to Archaeolo[gy]* recently published by Basic Boo[ks].

y—an exhilarating setting for, per-
s, religious rites. The other buildings
large and well shaped, but, although
red, little remains there except their
ide walls. The observatory, so called
use it resembles other structures
Mesoamerica that were used for as-
omical studies, is badly overgrown,
only its general, round shape can
iscerned. The wall, more than twenty
high, runs along the western
ler of the site for about seven hun-
l feet until it meets a deep gorge
cuts through much of the site. Both
wall and gorge would have afforded
l protection to the town. The wall,
ever, had been reconstructed in the
y part of the twentieth century, and
ıer investigation would be necessary
etermine how much of it was in-
ted by its reconstructor. I fixed the
tion of the site in relation to a land-
k (the church steeple of the mod-
town of Huexotla), drew a sketch
, measured the wall, took photo-
hs, and recorded all other relevant
before leaving.

ıe next two sites on my agenda were
ıe state of Puebla, about one hun-
and twenty miles southeast of
ico City. The first was Huaquechula,
h Cortes described in a letter to
les V, dated October 30, 1520, as
ated in a plain bounded on one side
ery high and rugged hills, and on
other by two rivers about two bow
s apart, each of which flows through
deep and large ravines. There are,
equently, very few entrances to the
and those which exist are so rough
cend and descend, that it can hardly
ccomplished on horseback. The en-
city is surrounded by a very strong
of stone and mortar, the outside
g about twenty feet high, while from
nside it is about on the same level
the ground. There is a battlement
g the wall three feet high, to pro-
them in fighting, and they have
entrances, broad enough for a man
ıter on horseback. At each of these
ınces, there are three or four curves
e wall, doubling one over the other,
above these turnings there is also a
ement on the walls, from which they
fight. They keep a great quantity of
orts of large and small stones all
g this wall which they use in fight-
It was this wall that I hoped to
at the site.

ıaquechula is now a poor com-
ty, with its houses badly in need
epairs and its plazas filled more
weeds than grass. Yet it boasts a
tiful seventeenth-century church
marvelous painted walls and carved
work, as well as some once elegant
es with lovely inner courtyards that
from the same century. But finding
own is not the same as locating the
l site described by Cortes. In such

a situation, local people are sometimes a help, but one soon learns that while they may know of "an old wall" or other ancient structure nearby, their directions are often too vague for a stranger to follow. I decided to ask for a guide.

The guide I found knew of no old walls there, but he did know of an abandoned building near a deep ravine outside the town. The building turned out to be modern, but near it, between the ravine and the town, is a rise of land that continues for some distance around the town. Although the land is overgrown, I found potsherds and worked obsidian on its surface, which indicated that I was on an archeological site. I also found large, broken stones that could have been part of the wall Cortes had described, and the shape and height of the slope suggested that portions of the wall had perhaps fallen and gradually become covered over with soil and foliage. Unfortunately, on this brief reconnaissance, there was not enough time to dig test trenches that might have yielded evidence of artifacts and made it possible to determine if this was indeed Cortes' wall. I did, however, make the appropriate notes and photographs.

The next two sites I investigated—Izúcar de Matamoros and Cacaxtla—also failed to furnish substantial evidence of military features. As Cortes had described Izúcar de Matamoros (its pre-Hispanic name was Itzocan):

"This city may have some three or four thousand households, and its streets and markets are well laid out. It has one hundred mosques and strong oratories with their towers, all of which we burnt. It stands on a plain at the foot of a medium-sized hill, where they have a very good fort, and, on the other side towards the plain, it is surrounded by a deep river which flows near the wall, which is thus surrounded by the deep ravine of the river. Over the ravine they have made a battlement, about six feet in height, which extends all round the city, and all along the wall they had placed many stones."

Unlike Huaquechula, Izúcar de Matamoros is today a good-sized city, much larger than the original Itzocan, and although it seemed unlikely that the battlement could be located, perhaps at least the fort could be found. I questioned the local people, and was led to a hill west of the city. The eastern rise of this hill is densely covered with potsherds and cut stone, and the western rise is more sparsely covered with the same material. Almost at the crest is the outline of a stone structure. Its maximum dimensions are about 95 feet by 63 feet, and it is divided into six irregular sections. It would have been difficult to establish that this bare outline was, in fact, the remains of a fort.

The Cacaxtla fortification, in the

: of Tlaxcala, had served for a time e Aztec period to protect the people ie state from attack by neighboring ula. One archeological report de- bes the site as a hill protected on sides by deep gorges and surrounded litches cut into the rock. After two of searching, I located the hill and leep gorges, but the hill is so badly ed that the ditches have only an rphous form.

Clues to the Past

ɪᴇ fifth and, as it turned out, the ast site of the survey was Tepexi iejo in the state of Puebla. Located it sixty miles southeast of the city 'uebla, it was visited in 1807 by a ich traveler named Dupaix, who rted that one building there con- ted a fortification system. Dupaix's rvations, however, were cursory be- e snakes that lived within the struc- discouraged any close investiga- . Armillas described Tepexi el Viejo 951 as a hill-fort site protected by s, moats, and "a bastion with loop- s." Another Mexican archeologist, nen Cook de Leonard, reported in that archeologists seldom visited area because it was notorious for ults made on travelers." According er, the major part of the site con- d of a unified fortress. In addition, noted pyramids, a palace, and a ber of other structures.

ie nearest modern town to this site epexi de Rodriquez; the route be- n them winds over hills and around gorges, and the one road that runs the ruins was impassable with my A guide from the town knew the ral direction, and although it took hours to walk to the site, the path remarkably direct; we took few turns and seldom backtracked. As iade our way along the top of a hill, h was bordered on three sides by gorges, we passed a cornfield filled potsherds, worked obsidian, and tone. Then suddenly, when we were of the foliage, the ruins were di- y in front of us. The effect was ling. Although both the guide and w something about Tepexi el Viejo, id not expect it to be so extensive in such good condition. Its pre- d state, along with its isolation, gave ie feeling of coming upon a town had only recently been abandoned.

e main sector of this site is on an ped flat hill that extends about 750 in both east-west and north-south tions. There are two great mounds e site, and two smaller ones, as well o buildings, each containing about ooms. Nearly two dozen additional s are found on lower levels in the iern sector of the hill. The most rkable aspect of the site is the huge that goes around the perimeter of the main sector. It was built against the side of the hill, and in some places is more than fifty feet high. Its position on a hilltop, the impassable gorges on two sides, and the large encompassing wall furnished Tepexi with excellent protection against assaults.

I fixed the position of the site in relation to the church steeple of Tepexi de Rodriquez, about four miles away and barely visible, and drew a sketch map of the main sector, roughly placing on it the mounds, buildings, and rooms. I also took about seventy photographs, wrote a detailed description of the site, and recorded information on the geography of the area and on other pertinent facts, such as access to the site and the possibility of setting up a camp in the nearest village.

Sometime later, when I studied the data I had collected from visiting five sites (Molcaxac, the sixth, was abandoned because of insufficient information concerning its location), it was clear that Tepexi el Viejo presented the best opportunity to study the problem of military organization in the Aztec period. It was in a good state of preservation and was clearly a site with military features. I arranged to launch an investigation the next summer, when a full map of the site and a plan of the structural remains would be made, and test trenches dug so that artifacts could be analyzed.

A description of the military features of Tepexi el Viejo should help to clarify the character of other fortified towns of the Aztec period, and a comparison of the artifacts with artifacts from other sites should indicate the relationships of this town to the Aztec capital of Tenochtitlán and other fortified towns. Ultimately, then, the investigation may lead to an understanding of the nature of military organization in ancient Mexico.

On the face of it, a site survey seems far from an intellectual activity, but that is precisely what it is. To be sure, there is a great deal of physical effort involved —climbing hills, stumbling into gorges, and trudging over miles of barren land —but the driving force is professional purpose. For the archeologist, the goal is not to find just *any* site, but to find one that will help him better to understand some particular aspect of the culture and history of the vanished past.

This list details the photographer, artist, or other source of illustrations, by page.
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51—Robert F. Smith
52-54—Helmut Wimmer except 53—Eugene Harlan, Lick Observatory
55—AMNH
60—F. York

Suggested Additional Reading

LOCOMOTION WITHOUT LIMBS

SIDEWINDING LOCOMOTION IN SNAKES. R. Cowles. *Copeia*, Vol. 4, pages 211-214, 1956.

TERRESTRIAL LOCOMOTION WITHOUT LIMBS. C. Gans. *American Zoologist*, Vol. 4, No. 2, pages 167-182, 1962.

HOW ANIMALS MOVE. J. Gray. University Press, Cambridge, 1953.

ON THE LOCOMOTION OF SNAKES. W. Mosauer. *Science*, Vol. 76, pages 583-585, 1932.

SUBTROPIC FLORA THRIVES ON 50TH PARALLEL

THE ENGLISH GARDEN. E. Hyams. Harry N. Abrams, Inc., N.Y., 1964.

EARLY MAPPING OF THE LAND AND SEA

THE STORY OF MAPS. L. A. Brown. Little, Brown and Co., Boston, 1949.

MAPS AND THEIR MAKERS. C. R. Crone. Hutchinson House, London, 1953.

THE WORLD IN MAPS. W. W. Jervis. Oxford University Press, N.Y., 1938.

EARLY ATLASES and COLOUR IN MAP-MAKING. R. A. Skelton. *The Geographical Magazine*, London, April, 1960, pages 529-553.

INVERTEBRATE LEARNING

THE FUNCTIONING OF THE STATOCYSTS OF OCTOPUS VULGARIS. B. B. Boycott. *Proceedings of the Royal Society of London*, Series B, Vol. 152, pages 78-87, 1960.

PROPRIOCEPTION AND VISUAL DISCRIMINATION OF ORIENTATION IN OCTOPUS. M. J. Wells. *The Journal of Experimental Biology*, Vol. 37, pages 489-499, 1960.

TASTE BY TOUCH: SOME EXPERIMENTS WITH OCTOPUS. M. J. Wells. *The Journal of Experimental Biology*, Vol. 40, pages 187-194, 1963b.

LEARNING AND DISCRIMINATION IN THE OCTOPUS. J. Z. Young. *Biological Review*, Vol. 36, pages 32-96, 1961.

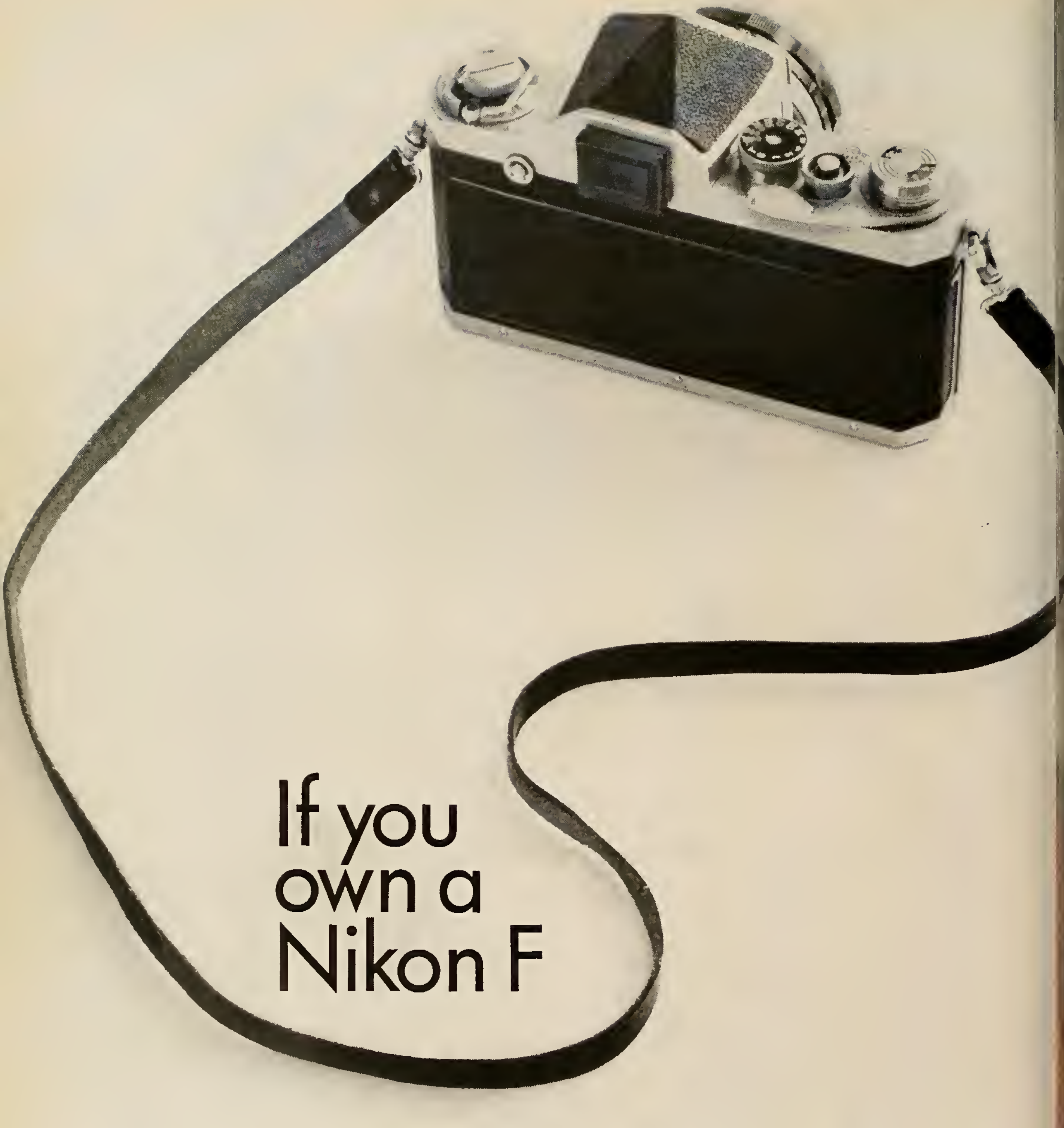
BEETLE'S SPRAY DISCOURAGES PREDATORS

CHEMICAL DEFENSES OF ARTHROPODS. L. M. Roth and T. Eisner. *Annual Review of Entomology*, Vol. 7, pages 107-136, 1962.

DEFENSE MECHANISMS OF ARTHROPODS. XII. J. J. Hurst, J. Meinwald, and T. Eisner. *Proceedings of the Entomological Society of America*, Vol. 57, pages 44-46, 1964.

DEFENSE MECHANISMS OF ARTHROPODS. XIV. Y. C. Meinwald and T. Eisner. *Proceedings of the Entomological Society of America*, Vol. 57, pages 513-514, 1964.

DEFENSE MECHANISMS OF ARTHROPODS. XV. T. Eisner, F. McHenry, and M. M. Salpeter. *Journal of Morphology*, Vol. 115, pages 355-400, 1965.



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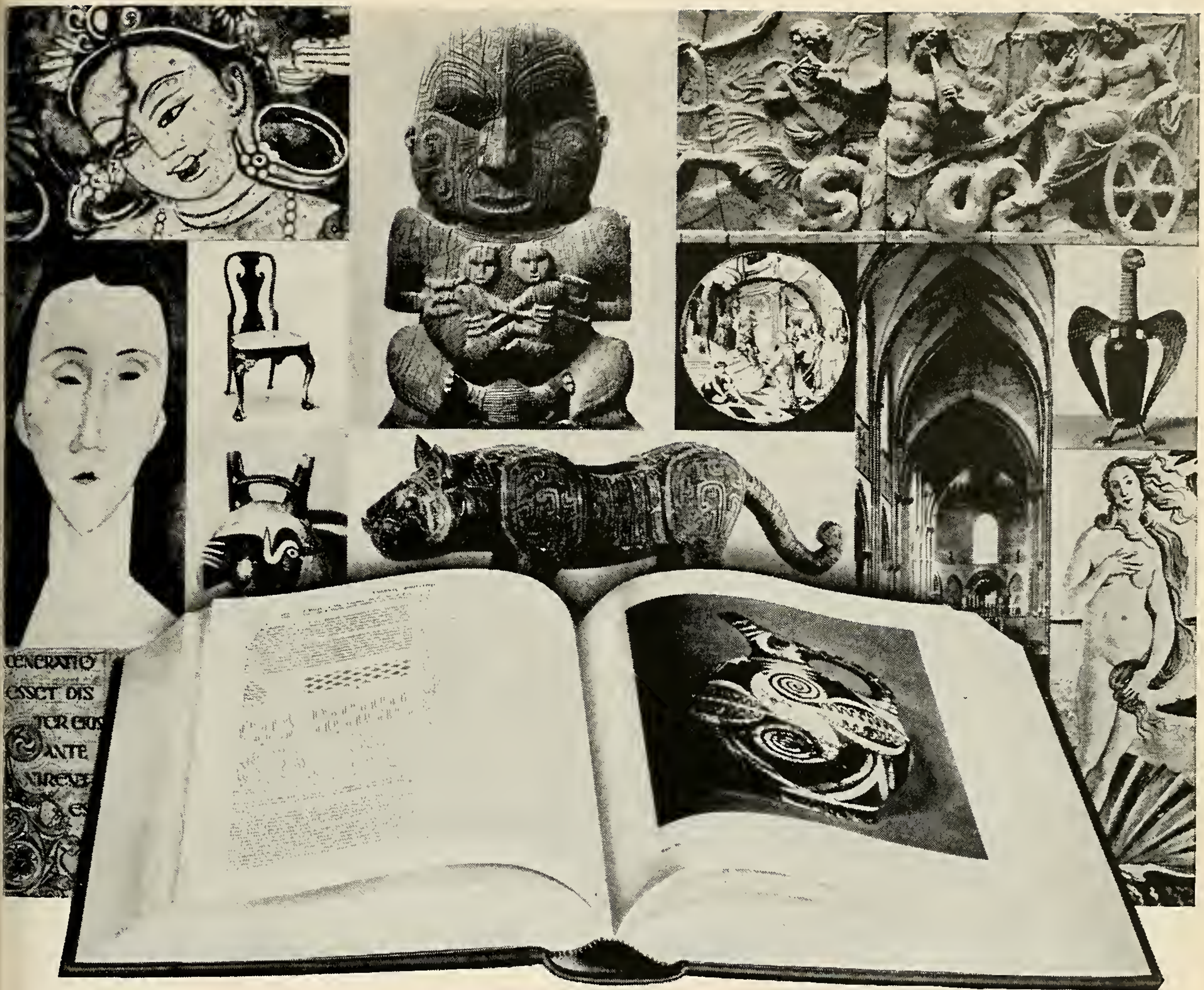
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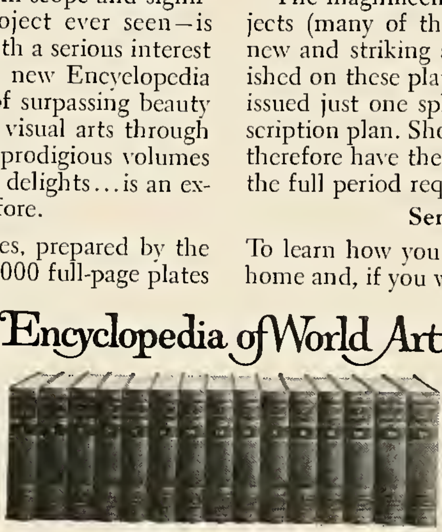

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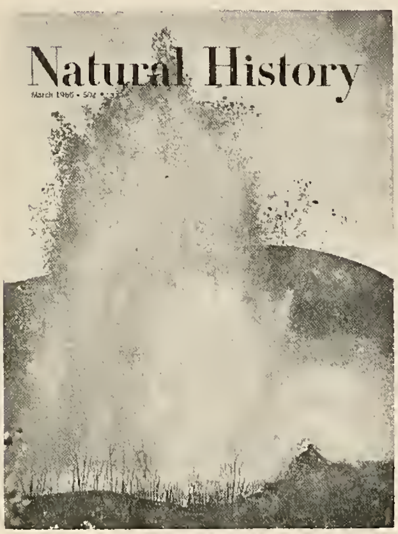
DEPARTMENTS



COVER: Margaret C. English, who has lived all of her life near Kilauea Crat describes her cover picture: "It was taken on Dec. 17, 1959 [near Kilauea I The fountain was about 1,000 feet high. This picture was from about a quar mile away, and believe me it was hot! Trees silhouetted against the fountain ohia lehua, about 40 feet high, and dead. Trees just a short distance back fr the edge were not killed. In an area covered by cinders and subjected to gr heat, trees have revived and are more beautiful than before, as cinder fall is very fertile." Article on Hawaiian Volcano Observatory starts on page

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BOOKS IN REVIEW

Herbals—old and new

By Elizabeth C. Hall

The Greek Herbal of Dioscorides, edited by Robert T. Gunther. *Hafner Publishing Co., $15.00; 701 pp., illus.* A Modern Herbal, by Maude Grieve. *Hafner Publishing Co., 2 vols., $25.00; 888 pp., illus.* Herbal, by Joseph Wood Krutch. *G. P. Putnam's Sons, $20.00; 255 pp., illus.*

Man's earliest interest in plants must have been occasioned by his need for food and, not much later (in the evolutionary scale), by his need to find useful materials that would support fire and could be fashioned into weapons and shelters. Certainly, too, long before the dawn of recorded history *Homo sapiens* had discovered and exploited additional advantages possessed by plants—flavors, scents, dyes, healing qualities, real or supposed; he had become a herbalist.

Nor were these discoveries confined to any one race of mankind or any particular geographic region. In time, trade in herbs and consequent travel developed as knowledge of their recommended, particular virtues spread. Merchants transported them across the ancient caravan routes of Asia; great trading companies of England and Holland established vast empires in tropical lands to further trade in spices; even today the price of pepper on the commodity exchanges of the world may be reflected in the cost of sausages. There is no doubt that the sciences of botany, medicine, and pharmacology derive directly from the ancient interest in herbs, as also, to a very large extent, does the art of gardening.

Our chief source of knowledge of the ancients' herb lore is the herbal of Pedanius Dioscorides, a physician born in Asia Minor in the first century A.D.—the time of Nero and Vespasian. He wrote of plants he observed in his military travels in many lands, and it is supposed that he was an army doctor. In his work he listed about five hundred plants and a few "metallic stones," and discussed what he believed to be their virtues for a wide variety of human ills and misfortunes. His herbal survived in the form of a sixth-century Byzantine manuscript, and was not reproduced by printing until 1478. The first edition appeared under the title *De Materia Medica Libri Quinque*, and was followed by a Greek text edition in 1499.

Strangely enough, no English translation was published until 1934, although an English botanist, John Goodyer, had made an interlinear English translation of the Greek text in 1655. This remaine in manuscript until 1933 when Robe T. Gunther edited it with few correctior (thus preserving the "atmosphere" o the translator's style), and the valuab historical document was published i 1934 by the University Press in Oxfor

In his preface, Mr. Gunther wrote "Many of the figures seem hopeless o interpretation. Nevertheless, we hav printed them, in the hope that field-bo anists . . . may thus recognize a few o the plants which through mistaken fe tures it has been impossible to identi . . . . The specific names with which w headed every chapter are perhaps le justifiable."

The present reprint edition, publishe by the Hafner Publishing Company New York, will permit herbalists, hist rians, gardeners, students of medicin and others to add copies of a botanic and horticultural classic to their libra ies. [We have received an announceme that the first facsimile edition of tl *Vienna Dioskurides* manuscript is to published in five annual numbers Akademische Druck-u. Verlagsansta Graz, Austria. Subscription price un June 30, 1966, will be $308.00 per nu ber. Non-subscription price is $400.0C

A Modern Herbal is an encycloped work in two volumes. It originated as collection of pamphlets written by t English author Maude Grieve about t time of the first World War, was lat amplified by information on Americ herbs and some others exotic to Gre Britain, and edited by Mrs. C. F. Le to produce the publication review here. Despite limitations almost inhere in a work developed in this fashio there is some unevenness of treatment the many kinds of herbs—this is a m useful and valuable book. It is by means a compilation. Mrs. Grieve wri authoritatively from her own experien as an herb grower and herb collect and from careful observations of t plants she knew so well. An extraor nary amount of information is present including folklore, so that this is one the most important books on its subje

A grave failing (to be corrected i separate supplement) is the omission an index of scientific names. The pla discussed are dealt with alphabetica according to their common names, practice most discouraging to any who values exactness and order. M Grieve's *A Modern Herbal* was ori nally published by Oxford Univers

About Stonehenge Decoded—

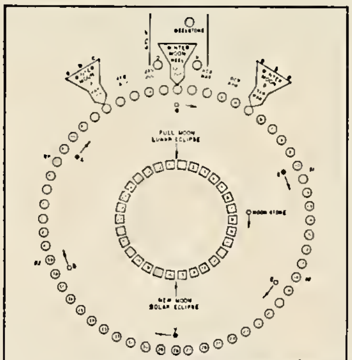
a new book reviewers are calling "as fascinating an archaeological detective story as our time has seen."*

"Stonehenge is unique. In all the world there is nothing quite like the gaunt ruin which Henry James said 'stands as lonely in history as it does on the great plain.' What purpose did it serve? Was it a city of the dead? A Druid place of horrid sacrifice? A temple of the sun? A market? What was it . . . and when?"

With these words, Gerald S. Hawkins begins the account of his dramatic evidence that ancient England's "Druid temple" was actually a sophisticated, brilliantly conceived astronomical observatory . . . a Neolithic computer designed and used by three different groups of people over a 400-year period beginning about 1900 B.C. STONEHENGE DECODED is the full story of how a twentieth-century astronomer – and sixty seconds of computer time – solved one of the great puzzles of the ancient world.

Dr. Hawkins, a professor of astronomy at Boston University and astronomer at the Smithsonian Astrophysical Observatory, first became interested in Stonehenge a dozen years ago, while working at a nearby missile-testing base just north of the ancient monument. Challenged by the known astronomical fact that the main axis of Stonehenge is aligned to the midsummer sunrise, he returned to Stonehenge in 1961 to photograph the phenomenon for himself. Immediately he became aware of questions which the massive stones themselves seemed to pose:

- **Why had the midsummer sunrise alignment been so beautifully and precisely established?**
- **Why were the great archways so astonishingly narrow, restricting the observer's view as sighting instruments do?**
- **Most important, if the monument's original purpose had merely been to mark the midsummer solstice, why had the many other stones – the many other precise alignments and controlled vistas – been so painstakingly erected?**


Stonehenge computer; schematic plan.

How the computer was used

"I felt that my field of observation was being tightly controlled, as by sighting instruments . . ." Dr. Hawkins speculated on the possibility that Stonehenge might have other solar alignments – and immediately realized that to answer this question would require a great volume of trial-and-error work well suited to computer analysis. He and his programmers gave the computer specific pertinent information about the positions of the stones at Stonehenge and the stars, planets, and other bodies of the sky. In his words, "it was as if [we] told the machine to stand at each of the selected points, look across each of the other points to the horizon, and each time report what spot of the sky it saw." The task took the computer less than a minute. The results were astonishing.

The dramatic facts were these: Each significant stone aligns with at least one other to point to some extreme position of the sun or moon. The mysterious circle of 56 "Aubrey" holes that ring the arches was probably used as an eclipse predicter. Stonehenge was an astronomical observatory and a good one. In fact, Dr. Hawkins believes, Stonehenge astronomy was so sophisticated that its Stone Age astronomers had apparently observed a phenomenon which had escaped modern astronomers: that eclipses of the moon occur in 56-year cycles.

Stonehenge Decoded

The full story of how these facts were uncovered, and what their significance may be, is told in STONEHONGE DECODED. The *Smithsonian Astrophysical Observatory News* calls it "a fascinating, explosive chapter [in] the 3500-year-old story." In addition to describing the astronomic discoveries, Dr. Hawkins, with Dr. John B. White, his collaborator, fills you in on the fascinating mythology that has grown up around Stonehenge, and on the remarkable techniques used in its construction. For, as archaeologists know, the building of Stonehenge, with huge stones carried across 100 miles of land and sea, was in itself a miraculous feat of construction. The book is indexed and illustrated with more than twenty brilliant photographs and endpaper maps of Stonehenge. It is a volume every reader of *Natural History* will want to read and own. For this reason, it is being offered on a special trial basis. Send the coupon for your copy now. If you are not completely fascinated by STONEHENGE DECODED, simply return the book within two weeks and owe nothing.

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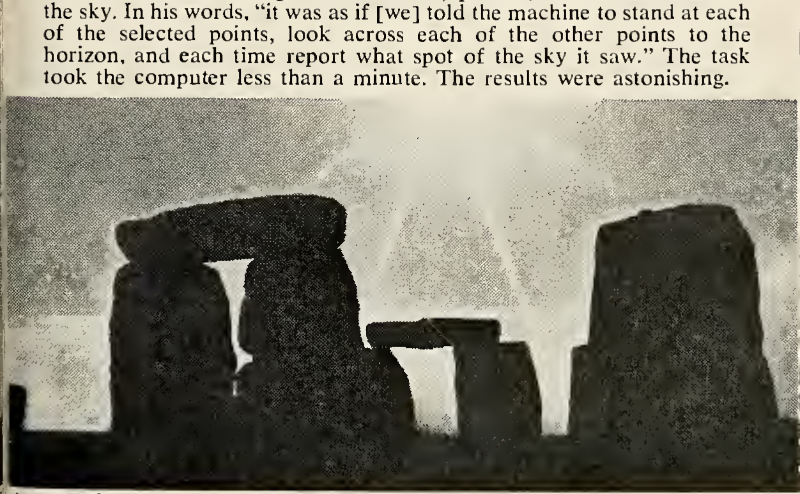

icago Tribune

Press in 1931. It soon went out of print and remained so until Hafner reprinted it in 1959 and again in 1965.

Extremely welcome is the handsome *Herbal*, the work of Joseph Wood Krutch. Beautiful in appearance and execution, delightfully written and lavishly illustrated, this production by such a well-known, gifted naturalist-writer is a pleasure to own and a joy to read. Mr. Krutch's study covers one hundred plants (and six creatures), each illustrated with a full-page reproduction of a beautiful sixteenth-century woodcut taken from Pierandrea Mattioli's huge folio volume, *Commentaries on the Six Books of Dioscorides*, issued in Prague in 1563 and Venice in 1565. Mr. Krutch's text is fascinating. He introduces his readers to the fundamental philosophy of the old herbalists—their conviction that each plant was a specific for some ailment and that it was the wise man's purpose to discover and make use of these God-given alleviants and remedies. Quotations from Theophrastus, Dioscorides, Gerard, Culpeper, and other herbalists and poets are frequent. Few new books in the horticultural-botanical field have so much appeal.

Elizabeth C. Hall is Associate Curator of Education at The N. Y. Botanical Garden and an honorary member of The Herb Society of America, N. Y. Chapter.

The World of the Tiger, by Richard Perry. *Atheneum, $6.95; 261 pp., illus.*

Tiger! tiger! burning bright." What a vivid picture William Blake's verse evokes. The tiger is "not just common flesh and bone and striped hide, but a kind of symbol of the jungle, of the cunning and cruelty and ferocity and incredible strength and beauty of raw nature," writes E. Marshall, one of the many authors quoted in this compendium of information on one of the most magnificent of our mammals.

Richard Perry has culled as many facts as possible from hundreds of references, and presented them in readable form. This is a difficult job at best, because the tiger is surrounded by folklore, half-truths, and the boasting of a lesser breed of hunters—a jungle of words at least as hard to penetrate as the reedy swamps of the delta of the Oxus River and of Lake Balkhash, once favored habitats of this animal. At long last, and in one book, we have honestly sought answers on questions of range, food, hunting habits, weight, size, coloration, mating, family life, relative keenness of various senses, fighting ability, man-eating proclivities, and even swimming ability. Destruction of habitat imperils the continued existence of the tiger more than any other factor. The author is perhaps rightfully pessimisti about survival of wild populations of th tiger much beyond the close of the twen tieth century. This presents a challeng ing conservation problem for India an the other countries of Asia.

There is an excellent selection of twelv superb black-and-white photographs an a frontispiece in full color by Yll There are several helpful features: short glossary; a map showing th approximate world range of the tige during the nineteenth century and mid-twentieth century; a useful index and an extensive bibliography. How ever, the section that treats scientif names of animals mentioned in th text is so riddled with taxonomic an orthographic errors as to be practical useless for the serious reader.

Hobart M. Van Deus
The American Museu

We Are Not Alone, by Walter Sulliva *McGraw-Hill Book Co., $6.95; 325 p illus.* The Quest, by Tom Allen. *Chilt Books, $4.95; 323 pp., illus.*

Perhaps the first widespread conte plation of creatures on other worl followed Galileo's discovery that t lunar terrain resembles terrestrial lan scapes. More recently, speculatio about moon men, Martians, and the li have been confined to works dubb science fiction to distinguish them fro "respectable" science. These specul tions attract a large following in spi of their ill repute in professional circl

Surprisingly, the split between t popular imagination and science has b gun to narrow. It was easy in the ear days to concentrate scientific inquiry the mysteries of immediate experien but now the efforts of scientists have be successful to the point where few my teries remain in the realm of everyd experience. Scientists have, therefo turned more and more to the questio of where the universe (and the wor within it) came from and how it h evolved. In particular, the problem the origin, or creation, of life has broug scientists back into the imaginative rea they comfortably ignored for so long. S nificantly, the vigorous modern techn ogy spawned by science has opened t previously inaccessible area of inqui For now, if life does exist elsewhere, may be experimentally verified by sat lite exploration or, should there be telligent beings, by radio communicati So while extraterrestrial life remains (this writing) hypothetical, the possibil has suddenly become acceptable many, although not all, scientists.

A thorough review of the availa evidence from various scientific dis plines for and against extraterrestr life is presented by *The New York Tin* science editor, Walter Sullivan, in


Crank

Are Not Alone. The occasional misinterpretations of scientific concepts do not significantly detract from the value of this informative book. After reviewing ancient ideas on otherworldly life, Sullivan considers the probability of planet formation near various types of stars, the synthesis of the large molecules of living creatures, and the possibility that life has been transplanted to the earth. Then he takes up the question of life on Mars and the other solar planets and thoroughly explains the problems of interstellar communication. The final chapter samples reactions to the theological problems raised by the possible discovery of intelligent life elsewhere. Sullivan presents his varied material in a readable and accessible style, and while his title betrays an optimism concerning the outcome of attempts to discover extraterrestrial life, he remains responsible to the skepticism of science.

In sharp contrast, Tom Allen in *The Quest* treats essentially the same material as Sullivan, not from the viewpoint of the scientist, but as a convinced believer in extraterrestrial life. In lively fashion, the favorable evidence, regardless of quality, is held up for the reader's amazement and approval, while scorn is cast upon dissenters. Less complete than *We Are Not Alone*, Allen's book is factually accurate and well written.

JAMES F. WANNER
Sproul Observatory

YOU, ME AND THE ANIMAL WORLD, by Martin Wells. *Houghton Mifflin Co., $3.50; 114 pp., illus.*

In his introduction, Martin Wells wonders whether or not he, as a scientist, can write about science for the intelligent layman. After reading this short book there should be no question that he can write very well. He is entertaining, charming, and whimsical. The book is a collection of essays, illustrated with the author's own delightful line drawings; text and drawings sparkle with humor.

Some of the subjects concern animals Dr. Wells knew particularly well—ants, snails, and assorted pets, many of which he does not recommend for household use. Other essays cover the aerodynamic problems of birds and insects, and the problems and hazards of an aquatic man —how much better it is, physiologically, to be a seal if you must dive.

In addition, there are chapters on animal design, the processes of design development through inheritance, the pros and cons of sexual reproduction, echolocation in bats, Dr. Wells' own recent experiments on learning and memory in the many-limbed octopus, and, finally, a note to science fiction writers to be aware of biological limitations when they create a new animal and expect it to function. The subject

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matter does seem spread about, for it is derived from his own researches, his lectures to students, and speeches to television audiences. But even with the diffuseness of subject matter, one theme continues throughout: there is much beauty in the design and function of adaptive systems that have evolved in animals in "hostile environments."

The study of biology under the guidance of Dr. Wells is an exciting experience. This book should catapult high school students into such a study, and provoke adults into further inquiry. An additional reading list is included.

EVELYN SHAW
The American Museum

PRECIOUS STONES AND OTHER CRYSTALS, by Rudolf Metz. Photographs by Arnold E. Fanck. *The Viking Press, $25.00; 191 pp., illus.*

THE title *Precious Stones and Other Crystals* is certain to provoke more than a cursory glance, and justifiably so. The first impression is of the vivid colors and the variety of forms so magnificently portrayed in the color plates.

The text is of an equal quality, and in lucid language presents a comprehensive survey of the nature, occurrence, form, and properties of minerals, with just the appropriate amount of emphasis on gem stones. The well-chosen bibliography is a valuable addition.

Because of the high price and the seemingly specialized format, this volume appears to be essentially a collector's item, which is unfortunate. The excellent text, accompanied by the remarkably faithful reproductions, presents a story that will interest anyone who has ever admired minerals.

D. M. VINCENT MANSON
The American Museum

FAREWELL TO EDEN, by Matthew Huxley and Cornell Capa. *Harper & Row, $15.00; 244 pp., illus.*

THE upper Amazon area of South America is one of the last regions in the world where "primitive" societies can still be found relatively unaffected by Western civilization. This book is a popular account of one such essentially aboriginal group, members of the Amahuaca tribe on the Inuya River, and of the changes facing them and other Indians in Amazonian, or eastern, Peru.

Much of the material on which the book is based was collected by Matthew Huxley during two brief visits to the Amahuaca and visits to other eastern Peruvian tribes in 1961. Huxley came to the Amahuaca at the invitation of anthropologists Robert Carneiro, of The American Museum of Natural History, and his wife, Gertrude Dole. They were engaged in making a thorough

ethnological study of the tribe, and made their field notes available to Huxley; the book benefits greatly from their contribution. On Huxley's second trip to the region he was accompanied by photographer Cornell Capa, who took most of the photographs with which the book is generously illustrated.

More than half of the book deals with the Amahuaca, one of the least acculturated Indian groups in the Amazon today. Formerly relatively numerous and occupying a wide territory east of the Ucayali River, the Amahuaca have suffered a great decline in population through the introduction of new contagious diseases, slavery, and other depredations. At the present time, the Amahuaca Indians described by Huxley consist of a small number of families that annually congregate for half the year at Varadero, a Summer Institute of Linguistics post on the Inuya River, and the S.I.L. is the primary agent of change in their lives. This is a North American organization with a multiplicity of educational and other purposes, but it is primarily evangelical in orientation. Robert Russell, the S.I.L. worker with the tribe, provides them with medical care and teaches them to read and write in their own language. This is intended to permit the Indians to read biblical texts in their native tongue, a basic objective of the essentially fundamentalist S.I.L. As Russell is quoted:

> "We have taught the Amahuaca a number of things about human nature which seemed entirely new to them. The first of these is that man is not basically good, but is basically bad, alienated from the life of God and deprived by sin from fellowship with God."

Thus "civilization" enlightens the "savage"! Yet compared with the other forces of change on the upper Amazon frontier, such as debt-peonage and even slavery, the opportunities offered the Indian by the S.I.L. for adjustment to the new conditions seem benevolent.

As a whole, Huxley's position is one of definite endorsement of the activities of the Summer Institute of Linguistics, which he sees as following a middle road between the Catholic missions' programs to assimilate the Indian completely and the North American-run evangelical missions' attempts to seal them off from the "outside evils." Huxley also visited some other tribes of the Peruvian Amazon, as well as the population centers of the Iquitos and Pucallpa, and the balance of the book concerns socioeconomic changes made in the tribes with S.I.L. help, and developments in the region as a whole.

This is an unusually informative work, extremely well written. Huxley brings to life the people about whom he writes in a way that most anthropologists can only envy. Cornell Capa's superb black-

and-white and color photographs, excellently reproduced, heighten the sense of personalized contact provided by the text. My only critical comment would be that Huxley's general knowledge of anthropology and South American ethnology sometimes leaves something to be desired, particularly when he attempts to make generalizations about upper Amazon Indian cultures as a whole or about structural relationships within Amahuaca society. However, such comparative and theoretical forays are few and minor in a book that can certainly be recommended as one of the most enjoyable and accurate popular works on the contemporary situation of the Indians who live in the upper Amazon.

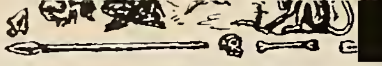
MICHAEL J. HARNER
University of California, Berkeley

PLANT DRUGS THAT CHANGED THE WORLD, by Norman Taylor. *Dodd, Mead & Co., $5.00; 275 pp., illus.*

MR. TAYLOR is a well-known and unusually prolific writer on botanical subjects whose previous works have been devoted primarily to garden plants. In this and in one previous volume he has turned his attention to plants of medical interest, a topic of considerable practical importance and current public attention, and one that permits some excellent yarn spinning. Modern man just didn't reach out of his bedroom window and pluck a few twigs that happened to cure his gout, or his malaria, or his ailing heart. The stories of the way our information has been accumulated, and the historical background for the codification of this information in the weighty *United States Pharmacopoeia*, form the basis for Mr. Taylor's volume.

A catalogue of the plants and the drugs they contain, as discussed by Mr. Taylor, will not provide anything more than a skeleton that can be fleshed out only by reading the book. Anesthetics, narcotic analgesics, tranquilizers, muscle relaxants, psychogenic drugs, poisons, and treatments for many organic diseases have been found in plants, which are still the primary sources for these drugs. To my mind, a noteworthy chapter is "The Cathartic Racket," which details the history of several of the drugs that in one form or another are the financial basis for what seems to be a good deal of evening television. Somewhat to my surprise, a "clean system" was of concern to the ancient Chinese and Egyptians, as well as to the considerably more modern Romans. It is of interest that the balanced Chinese used rhubarb, the fatalistic mid-easterner used senna, and the rugged Roman used (of course) castor oil.

Other chapters, particularly those dealing with the narcotic alkaloids,

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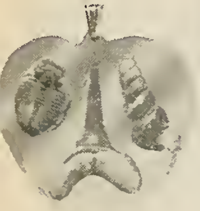

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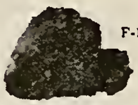

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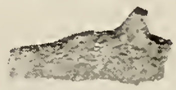

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— FOSSIL GLOSSARY —

CASSIOPE, Coalvillensis; Gastropod (snails) class of Mollusks. Cretaceous Period (63-135 million years old) (F-8).

CORAL, Fossil. A Coelenterate (coral, sea Anemones, hydros) from the Mississippian Period (310-345 million years old). Called "Horn coral" because of unique shape (F-10).

CRINOID STEM, (sea lilies), one class of the Echinoderm Phylum, Mississippian Period (310-345 million years old). Disc shaped plates comprise the stem (F-9).

DINOSAUR BONE, Jurassic Period (135-181 million years old). A relic of the reptilian monsters that once ruled the world. The cellular bone structure is clearly visible in this petrified bone fossil (F-14).

ELRATHIA, Kingi. Trilobite class of the Anthropod Phylum from the Middle Cambrian Period (approx. 500 million years old). Trilobites became extinct during the Permian Period and have no present descendents (F-15).

EXOGYRA, Arietina; Pelecypod (Clams, Oysters) class of Mollusks. Jurassic Period (135-181 million years old). Uniquely shaped, often called "Rams Horn" (F-4).

FERN LEAF, Fossil Pennsylvanian Period (310-280 million years old). Fern frond leaflets are visible in the magnificent fossil (F-12).

MUCROSPIRIFER, Mucronatus; var. Prolificum. Brachiopod (lamp shells), Devonian Period (345-405 million years old). Pyrite has replaced the original Brachiopod (F-6).

PACHYTEUTHIS, Densus; A Belemnite of the Cephalopod (Octopus, Squid) class of Mollusks. Cretaceous Period (63-135 million years old). Also known as "Sea Pens" because of their unique shape (F-7).

PETRIFIED WOOD. Triassic through cretaceous Period (230-63 million years old) (F-11).

RHYNCHONELLA, Uta; Brachiopod (Lamp shells), Triassic Period (181-230 million years old) (F-2).

SHARK'S TEETH, Miocene Period (approx. 12 million years old). Beautifully preserved, color black & slate gray (F-3).

SPONGE, Fossil, Porifera (pore-bearers) Triassic Period (181-230 million years old). Shows the pores typical of these sponges (F-13).

TURRITELLA in agate Matrix. Miocene Period (approx. 12 million years ago). Agatized Turritella in polished agate stone, showing graceful fossil sections (F-1).

TURRITELLA, Gastropod (snails) class of Mollusks. Miocene Period (approx. 12 million years ago). Original Turritella uniquely replaced by semi-precious agate (F-5).

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which are still a blessing rather than a social curse, and the one on quinine (did you know that the Society of Jesus had a virtual monopoly on this drug?) are fascinating.

No reviewer can let an author off scot free. The illustrations are scanty and uninformative.

RICHARD M. KLEIN
The New York Botanical Garden

OLDUVAI GORGE 1951-1961: FAUNA AND BACKGROUND, by L. S. B. Leakey. *Cambridge University Press, Vol. I, $14.50; 118 pp., illus.*

FOR well over thirty years L. S. B. Leakey has been exploring, excavating, and collecting in the Olduvai Gorge and its environs of East Africa, searching tirelessly for every scrap of evidence he could find relating to human occupation, man himself, the fauna associated with him, and the geologic and environmental background to all of it.

The Gorge, a part of the Great Rift Valley that parallels the east coast of Africa, is a remarkable geologic phenomenon that has exposed in layer after layer the sequences of Pleistocene history. From the face of this cliff Leakey has accumulated a vast assemblage of fossils illustrating the faunas that once inhabited the area. Recently, his patience and persistence were rewarded by the discovery of a series of early hominids that have turned out to be key finds in tracing the evolution of man.

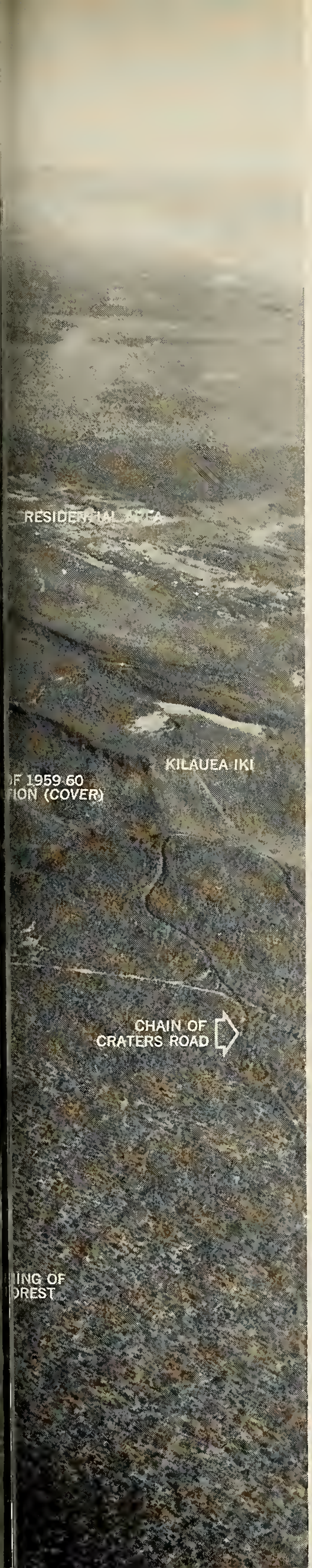
For these reasons Leakey and Olduvai are synonymous, and both are well known to all students interested in paleontology and human evolution. Scholars in these subjects have been eagerly awaiting the reports on the discoveries, but since the work is still in progress and completion of detailed reports is a slow, laborious process, only brief and necessarily inadequate notices have appeared thus far. With this volume, Leakey is making available interim assessments of the material he and his colleagues have collected. This is presumably the first in a series, and it deals mainly with the geologic and climatic setting and the mammalian fauna.

It is already clear that the current results make re-evaluations essential. The dating of Bed I, where *Homo habilis* and *Zinjanthropus* were found, appears to be definitely Villafranchian and, therefore, Early Pleistocene. Many of the identifications of mammalian fossils have been radically altered and revised, indicating far more of a break between the earlier levels and recent times than previous studies had suggested.

Despite some faults in presentation, this is a most welcome book, and it will be widely consulted.

HARRY L. SHAPIRO
The American Museum


MAUNA KEA
MAUNA LOA
N.E. SLOPE
FLOWS
VOLCANOES NATL.
PARK HDQRS.
U.S.G.S. VOLCANO
OBSERVATORY
KILAUEA CRATER
(CALDERA FLOOR)
1954 LAVA FLOW
HALEMAUMAU
FIRE PIT
VISITORS' PARKING
KAU DESERT AREA



Volcanoes Tell Secrets in Hawaii

by HUGH H. WAESCHE and DALLAS L. PECK

INCREASED understanding of volcanic phenomena, and much basic new knowledge of all that goes on beneath the earth's surface, have resulted from more than half a century's work by scientists at the U.S. Geological Survey's Hawaiian Volcano Observatory. The possibility of actually predicting eruptions has been greatly improved. Better techniques for probing geological secrets have been developed.

The Observatory is virtually an earth sciences clinic, and it is uniquely situated for studying its principal patient. It directly overlooks the three-mile-wide crater, or caldera, of Kilauea (KEY-la,oo-WAY-ah) Volcano in Hawaii Volcanoes National Park on the island of Hawaii. From the highest point of the caldera's northwest rim, the Observatory staff can watch the lava-covered floor 500 feet below. There, a mile to the south, is a fire pit, three-fourths of a mile in diameter, called Halemaumau (HA-lay-MA,oo-ma,oo). Although quiet now, the fire pit has been the principal center of activity at Kilauea throughout historic time, and boiling lava was visible in it most of the time from 1823 to 1924.

Two miles to the east, the crater of Kilauea Iki (Little Kilauea), with its orange-topped cinder cone, may be seen just outside the caldera. In late 1959 this was the scene of the most spectacular Kilauea eruption of modern times.

To the southwest, stretching from Halemaumau to the sea 20 miles away, are the gaping surface cracks of the Kalauea southwest rift zone.

Twenty-eight miles to the west is the 13,680-foot summit of Mauna Loa (MA,oo-na LO,ah), the world's largest active volcano. As seen from the Observatory, its graceful slopes sweep across the western and northern skyline for 75 miles. On its slopes are countless lava flows that have issued from the volcano's northeast and southwest rifts that join at Mokuaweoweo (mo-KOO-ah-WAY,o-WAY-o), the summit caldera.

Thirty miles to the north, across the northeast flank of Mauna Loa, is the snow-capped, 13,780-foot summit of dormant, or possibly extinct, Mauna Kea (MA,oo-na KAY-ah) Volcano.

This, then, is the setting for the Hawaiian Volcano Observatory. The world's other observatories are near or on the volcanoes under study, but few, if any, can command such a dramatic panorama of volcanic features.

The Observatory was founded in 1912 by the late Dr. Thomas A. Jaggar in order to study both the practical and theoretical aspects of volcanology. It was supported during the first few years by the Whitney Fund of the Massachusetts Institute of Technology and by the Hawaiian Volcano Research Association, but in 1917 support was shifted to the federal government. Since 1948 it has been operated by the U.S. Geological Survey with the encouragement of the National Park Service. The Observatory was founded because of the need for direct observation of volcanic processes, and because of a "sincere belief that a systematic and continuous study of

Summit of Kilauea Volcano on the island of Hawaii serves as a veritable clinic in the earth sciences. Sheer sides of larger crater drop 500 feet to the floor of congealed lava.

Angle of tilt of its sides changes as a volcano expands, contracts with changes in the pressure from deep underground.

volcanoes would result in the protection of life and property." To accomplish this objective, prediction of volcanic behavior became one of the major aims.

At an early stage in the Observatory's history, daily visual observations were supplemented by the continuous, quantitative instrumental observations that are necessary for deciphering the structure of the volcano and the processes going on within it. The obvious association of volcanic activity and earthquakes made seismic studies mandatory. Abrupt increases in seismic activity are, at times, premonitory to eruption, and the site of unusual swarms of earthquakes can indicate where lava may break out.

To determine the location of an earthquake and its depth, seismometers at three or more sites are necessary. Signals from a network of six seismometers clustered about the summit of Kilauea are transmitted via telephone wires to the Observatory, where they are recorded on smoked drums. Unusual seismic activity can be spotted on these records as soon as it occurs. Additional seismographs that were designed to record both nearby and distant quakes are situated in a vault at the Observatory and at five sites around the perimeter of the island. Other seismographs are at the summit of Mauna Loa and at Haleakala on the island of Maui.

Seismic studies at the Observatory show that earthquakes are frequent, although most of them are not felt except by sensitive instruments. Before, during, and after eruptions—and at certain other times not immediately associated with eruptions—these may total 1,000 or more a day; even during quiet times between eruptions, 50 to 100 quakes a day from shallow sources beneath Halemaumau are recorded. In addition to normal earthquakes, the seismographs record another phenomenon that has been called harmonic tremor. It appears on a seismogram as a long-continuing motion, somewhat like sine waves, with a period of about one-half second. These waves are identified with the movement of molten lava either at the surface during fountaining of a volcano or during underground flowage. Eruptions of Kilauea are preceded by harmonic tremor for several hours; such tremor thus provides a short-time warning of impending eruption. Harmonic tremor accompanies all eruptions; it is a specific part of an eruption's autograph.

Records from the seismographs are read daily, and all large earthquakes are located. This is a formidable task, particularly during times of great activity. Large distant earthquakes, as well as local ones, are studied, for they serve notice on the possible occurrence of tsunamis—the seismic sea waves that have devastated coastal areas of Hawaii, one as recently as 1960.

Since the founding of the Observatory, the staff has been intrigued by the possibility of predicting eruptions by changes in tilt of the ground surface at the summit of the volcano. Early attempts were severely hampered by the type of instrument used and by the site—unfortunately the Observatory turned out to be on a fault block that teeters inward and outward with the seasons, obscuring more fundamental changes in tilt. During the last nine years, studies of tilt have been more successful. The primary instrument now used is a water-tube tiltmeter modified from a Japanese design. These instruments consist of brass waterpots (mounted with micrometer screws and glass lenses), which are joined by water and air tubes. They operate like a water trough; when one end is elevated, the water level is raised in one pot and lowered in the other. Although simple in design, they are remarkably sensitive; such an instrument could detect the tilting produced by lowering one side of Hawaii only one inch with respect to the other side, 70 miles away.

One water-tube tiltmeter is permanently mounted in the vault at the Observatory and read daily—or more often during times of volcanic crisis. Other water-tube systems are portable and are used to relevel the fixed concrete piers at many tiltbases around the summit of Kilauea. These bases are releveled every few months.

The network of stations around the summit of the volcano shows that tilt is primarily radial and results from the swelling and shrinking of the volcano in response to movement of lava beneath the summit. Increases in upward pressure cause the sides of the volcano to swell outward, and this changes the angle of inclination of the ground in relation to the horizon. The nearer the summit, the greater the tilt. Analysis of the data suggests that the variations in pressure originate in a shallow reservoir of magma (molten lava) at a depth of perhaps two and one-half miles below the south end of the caldera.

Changes in tilt parallel the cycles of volcanic activity. As the reservoir slowly fills with lava after an eruption, the volcano swells; when the reservoir is so distended that the fluid pressure exceeds the strength of the enclosing walls, the walls rupture, the lava escapes from the reservoir—usually to the surface in an eruption—and the volcano rapidly deflates. This has been the pattern during the several flank eruptions of the last six years. Tilt measurements allow a general day-to-day evaluation of the state of the volcano, rather like the evaluation of fire danger in the national forests. We know whether the reservoir has little lava and is unlikely to erupt, or whether it is gorged with lava and almost ready to erupt. Unfortunately, the rate of inflation is not constant, and the level of tilt is not the same at each eruption; consequently, an exact prediction is not yet possible.

Inflation and deflation of the volcano can also be detected by precise measurement of horizontal distances across the summit. By use of a geodimeter (a device that employs a modulated beam of light for ultra-precise distance measurements), a shortening of 11 inches was detected in a 10,000-foot line across the summit caldera of Kilauea during the deflation accompanying the March, 1965, eruption. This suggests a method of monitoring the state of volcanoes where the use of water-tube tiltmeters is impractical, such as at the summit of Mauna Loa

Night view of a late stage of 1959-[60] Kilauea eruption shows fountain to t[he] rear, cracks in lava flow in foregroun[d]

Mauna Loa looked like this on the first night of eruption, April 7, 1940. The glow is 7 miles across at base. View is from Observatory 25 miles away; a cloud bank lies between.

Daytime view of the same eruption, taken close-up later in April, shows how the energy of outbreak at Mokuaweoweo summit crater of 13,680-foot-high Mauna Loa, has subsided

where temperatures go below freezing every night of the year. In July, 1965. two geodimeter lines were established across Mokuaweoweo; when they were remeasured in December, 1965, they showed no change, indicating that Mauna Loa is not inflating and hence that an eruption soon is unlikely.

Physical measurements of the earth's surface also provide knowledge of changes in the shape of the volcano. Geological Survey engineers established many bench marks on Kilauea and determined their relative horizontal positions by triangulation and their altitudes by leveling, in order to establish primary control for making accurate topographic maps. These measurements, begun in 1913, have been repeated many times. For example, accurate measurements of the elevation above sea level of a bench mark near the former site of the Observatory at the northeast edge of the caldera, made in 1920 and again after the explosive eruption of 1924, showed that the area had settled four feet. The caldera floor near the Halemaumau fire pit, center of the violent 1924 activity, settled an additional ten feet. Some of the level lines on Kilauea are now rerun by the staff of the Observatory after every major volcanic episode. Recently a close network of bench marks was placed on the floor of Kilauea caldera. Accurate level measurements are made between these periodically to locate the center of swelling and deflation of the volcano.

To supplement tilt and level measurements, the staff of the Observatory long ago began gathering data on the concentric faults around Halemaumau, which appear on the surface as great cracks. The distances across the cracks at selected sites are measured regularly with a tape (this program is now maintained by rangers of the National Park Service). When these distances increase rapidly, it can be predicted that massive landslides into the fire pit are imminent. Since the public ordinarily has ready access to the unprotected rim of Halemaumau, these forecasts are important for public safety. As a result of this program, the public observation platform at the edge of the pit was moved in 1960; a few days later the ground beneath the abandoned site collapsed into the pit.

By careful comparison of all the observations—such as the number of earthquakes from different areas and depths, and the state of swelling of the volcano as determined by tilt, level, and geodimeter measurements—a general evaluation can be made of the state of the volcano; that is, whether an eruption is likely or unlikely, and whether the eruption is most likely from the summit or from one of the rift zones. Strong harmonic tremor and associated swarms of shallow earthquakes give more reliable but shorter-term indication of an impending eruption. But even these may be misleading; at times, as in May, 1963, lava left the summit reservoir, flowed underground down the rift zone, with associated strong tremor recording on the seismographs, but did not erupt at the surface.

As a result of all the gathering and analysis of data on the volcano (plus or minus a goodly dose of luck), some remarkably successful predictions of eruptions have been made in the recent past. And also some remarkably unexpected eruptions have occurred. The March, 1965, eruption in Makaopuhi (MA-ka-o-POO-hee) Crater was predicted in a general way from an analysis of tilt and seismic data two months before it occurred. Harmonic tremor gave two hours clear warning—long enough to warn federal and civil authorities, to gather together equipment for observing the eruption, to send a seismic crew to the area, and to station a man at Makaopuhi Crater one hour before the eruption broke out there. In contrast, the eruption on Christmas Eve, 1965, was almost completely unexpected. The volcano was only moderately inflated, and there was no seismic prelude until the onset of strong harmonic tremor and a swarm of earthquakes alerted scientists an hour before the outbreak.

LIKE firemen, members of the Observatory staff must always be ready for immediate action. From the instant of outbreak, regardless of the time of day or day of the year, the Observatory and the site of eruption buzz with activity. All but essential personal affairs and interests are put aside for the duration. If the eruption is nearby, some members rush to the scene of activity. Flows can often be approached to within a few feet, fountains to within a few hundred feet on the windward side; choking fumes and intense heat usually prevent close approach on the downwind side. The many recent eruptions in pit craters can be conveniently watched from the rim—with occasional sallies down the precipitous sides of the crater to the edge of the lake. In addition to fume and heat, another hazard is molten material thrown out by the fountains—volcanic bombs, pumice, and Pele's hair (Pele is the goddess of volcanoes in the old Hawaiian religion). The "hair," fine strands of glassy lava spun by the wind from molten droplets, may be a danger to the eyes as well as an irritation to the skin.

Hawaiian eruptions are relatively quiet and safe, however, compared to those of other volcanoes. They produce basalt—fluid lava that is relatively rich in magnesium and calcium and poor in silicon and alkalies. Spectators crowd toward the accessible eruptions instead of fleeing, presenting formidable problems in traffic regulations and public safety. The rangers of the National Park Service work long hours to keep the situation in hand, and most eruptions are viewed by orderly crowds at the site, with long lines of cars filled with people waiting their turn to see the spectacle.

The scientists at the scene measure and record every visible aspect of the activity. Dimensions, directions, and rate of movement of flows are noted, as well as the type of lava, height and length of fountains, rate of outflow, and extent of fumes. Such equipment as transits, levels, and stopwatches make the measurements as quantitative as possible. Photographs (stills and regular and time-lapse movies) are made of all phases of the eruption and systematically recorded.

Temperatures of fountains and lava flows are measured with optical pyrometers like those used by iron foundry men. The colors of incandescent materials are indicative of their temperature, and the red and orange color of the lava as viewed through the telescope of the pyrometer is compared with a glowing wire of known temperature. For best results the measurements are made at night, and, even then, fume between the lava and the observer gives rise to low apparent values. More accurate temperature measurements are made with potentiometers wired to thermocouples inserted directly into the molten lava.

Gathering samples of the new molten material is an important and sometimes difficult task for the volcanologists. Pumice raining down from the fountains is collected in pans or on canvas squares laid out on the ground.

Conventional aerial view of a section of Kilauea Volcano's crater, with Halemaumau fire pit at left and Kilauea Iki at right, is an example of the detailed photographic record that is kept by Hawaiian Observatory to study volcano's changes.

The time of collection is carefully noted, because significant shifts in composition take place during some eruptions. For example, during the 1959 eruption in Kilauea Iki Crater, the composition varied with the violence of fountaining; magnesium increased and silicon decreased during greater outflow, because more olivine crystals were swept out of the magma chamber with the lava. Some pumice samples are collected with particular care, using pans, glass jars, and surgical gloves that have been sterilized in advance. These samples are searched for inorganic precursors to living matter. Samples of lava are collected by hammering a chip off a newly "frozen" (congealed) flow, by scooping directly from a molten pool or stream with a long-handled dipper, or by wrapping a blob of the lava around the end of a ceramic tube or even a wooden stick. As protection from the intense heat of the molten lava, heat shields such as asbestos suits or hand-held aluminum panels are used.

Gas samples are collected in evacuated and sealed glass tubes with specially prepared tips. These are inserted into a gas vent, or directly into the lava, and the tip is broken off. The vacuum draws the gas into the tube, which is then resealed.

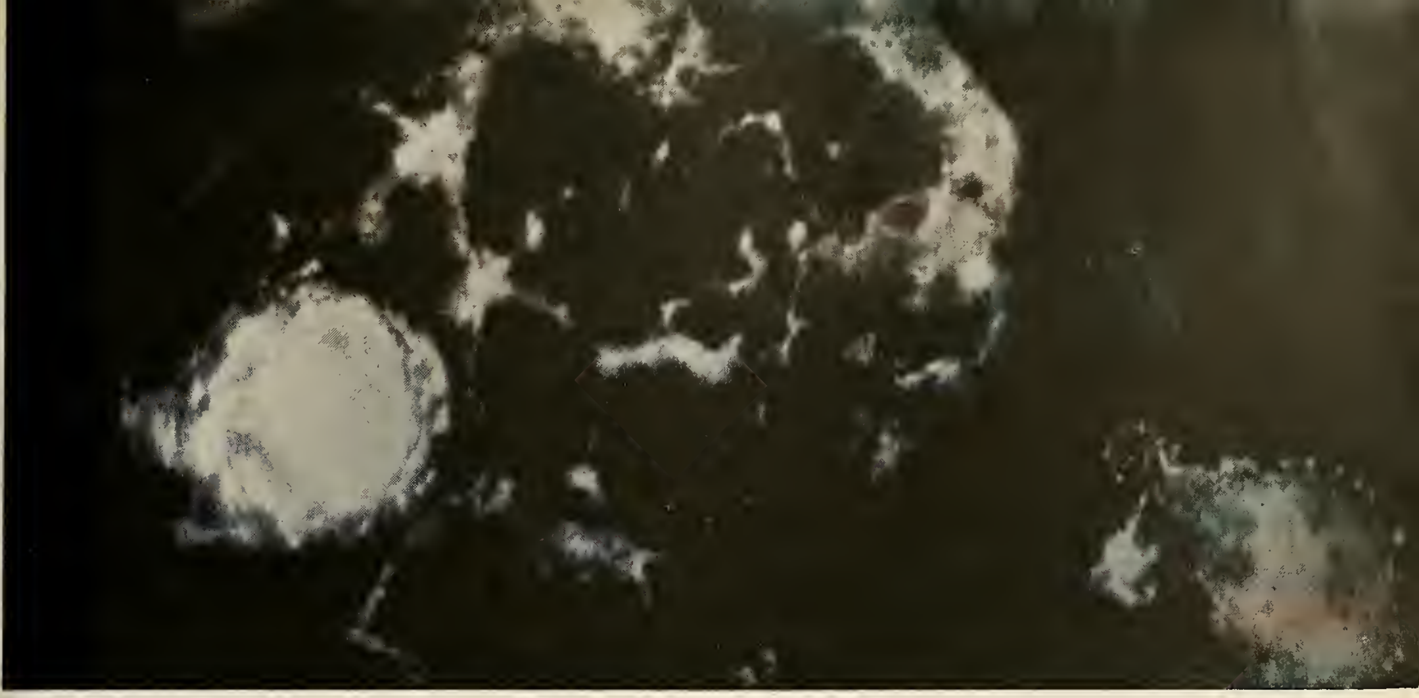
Portable seismic equipment is used to study earthquakes and harmonic tremor near the fountains and also to determine where new outbreaks of lava might take place.

If an eruption occurs in inaccessible terrain, such as high on the slopes of Mauna Loa or in the jungle east of Kilauea, it may be many hours or days before scientists can reach the scene. Meantime, evaluation is made by long-distance ground observation and by air reconnaissance, using observation planes supplied by the Air National Guard and the Civil Air Patrol. First consideration is given to determining the exact location and extent of the activity, and the potential danger to human structures and activities.

The scientists left at the Observatory during an eruption maintain the seismographs and study the seismic records. These have to be changed on the instruments for visual recording more often than usual; otherwise the traces of harmonic tremor and earthquakes would be so crowded that the records would be unreadable. Changes in tilt are measured on the water-tube tiltmeter in the vault on an hourly basis, and the progressive changes are plotted and carefully analyzed. The chemical laboratory may be busy with analyses of newly collected material; the results serve as guides to further collections during the eruption.

Meanwhile the Scientist-in-Charge has set up a "command post" at the Observatory. He co-ordinates the surveillance of the eruption, maintaining communication with scientists at the scene by means of radio and telephone. He notifies National Park and Civil Defense officials, Geological Survey headquarters, and the press at the time of the outbreak (before, if possible) and when any unusual activity develops as the eruption progresses. Daily summaries of the course of the eruption are issued to all concerned. Wives of the staff and friends of the Observatory pitch in to help answer the telephone and to prepare food and hot coffee for the busy workers.

LIFE does not return to normal until long after the eruption. The many earthquakes recorded on the seismographs have to be located, and the occurrence of tremor analyzed. Timing of tilt changes, seismic events, and variations in the eruption are carefully compared. Additional tilt, level, and geodimeter measurements are made and compared to those made before and during the eruption. Aerial photographs are taken of the eruption area, and the new lava flows and cinder cones are mapped on the photographs. The staff collects additional samples of the new lavas—a job that may entail flying into remote areas by helicopter or hacking through the jungle with machetes. Slices of the lava samples are cut to a translucent thinness and studied under the polarizing microscope. Other samples are analyzed in the chemical laboratory at the Observatory and at other laboratories of the Geological Survey. Some are crushed, sieved, and the minerals separated and studied. Eventually all of the data and conclusions are incorporated in one or more technical reports, thus adding a new chapter to the long-term study of volcanoes to provide a



Much more can be learned about heat changes by the use of infrared aerial photos, such as this one of the same area, than from conventional pictures. Infrared photos show the hot spots, thus helping to sense subsurface heat emission.

clearer understanding of how the world was made and of the changes that are still in progress.

Three eruptions of Kilauea during the last seven years ponded their flows in accessible pit craters, forming stagnant lakes of molten lava—the 1959 eruption in Kilauea Iki Crater, the August, 1963, eruption in Alae Crater, and the March, 1965, eruption in Makaopuhi Crater. These lakes are unique natural laboratories for study of the solidification of basaltic lava, and have become the centers for a major continuing effort by the Obser- vatory staff. The information gained ıelps increase our understanding of ɔlder flows in Hawaii and all over the vorld, and provides clues to processes going on at depth beneath the volcano.

Accessible lava lakes suitable for ıtudy are a rare occurrence in the vorld. The last comparable one in Hawaii formed in 1877. In most of he world's volcanoes, lava lakes form ɔnly in the summit craters, as in Hale- naumau, and are not safe to examine, nuch less study intensively.

Before the Hawaiian lava lakes ould be studied, ways had to be found ɔ move men and equipment from the im of each pit crater down to the lake urface. The lake in Kilauea Iki Crater vas accessible by trail when it formed. ut those in Alae and Makaopuhi were ot. The Observatory staff had to build ude trails, placing climbing ropes ver the steeper cliffs. They stretched ire cables down from the crater rim ɔ that equipment could be lowered. Water hoses, telephone lines, and wires for seismographs and temperature recordings were also fed down from the rim.

Many different methods are used in studying the cooling lakes of lava, but core drilling is the key. Holes are drilled with a portable rotary drill designed for mining exploration—a modified chain saw, mounted on a steel shaft and raised or lowered with a hydraulic pump. The drill uses special tungsten carbide bits that are cooled with water pumped through the drill stem. With this equipment, holes can be drilled completely through the solid crust of the lake and into underlying molten lava at a temperature of 1070° centigrade. Thirty-six holes (most of them 1⅛ inches in diameter) have been drilled so far in the three lakes; the longest, 55 feet in length, penetrated the upper crust of Alae lava lake, the partly molten center, and the lower crust, and passed into underlying lava formed in 1840.

For a few hours or days after a hole has been drilled into molten lava, devices can be forced down through the bottom of the hole and deep into the melt. Sometimes, but far from always, these can later be raised again to the surface. In this way hollow ceramic and steel probes have been pushed into the melt so that temperatures could be measured with thermocouples; temperatures as high as 1135° centigrade have been measured within probes in the molten lava 15 feet beneath the crust. The viscosity of the melt was also measured in a successful experiment that followed six frustrating failures over a period of three months. A paddle attached to a steel shaft was pushed deep into the melt and turned with weights hung from the shaft above the lake surface. The experiment indicated a viscosity of 5,000 to 10,000 poises, the first direct measurement of lava viscosity outside the laboratory.

The drill holes provide ideal chambers for the repeated measurement of temperatures and oxygen content and for the collection of volcanic gases. Core from drilling and from sampling tubes pushed into the melt beneath the holes provides material for investigation at the Observatory and at many other laboratories. Studies range from microscopic and chemical analysis to the measurement of thermal conductivity and magnetic susceptibility.

Many other techniques are being used to probe the secrets of the lakes. Grids of stations have been surveyed on each lake and are periodically reoccupied to take measurements of precise levels, magnetic field, gravity, and electrical conductivity. Fractures form in each lake as the crust cools and contracts. (These sometimes open with a loud bang directly beneath the investigator, a rather unsettling experience.) Repeated mapping of the newly opened fractures reveals their pattern of formation. Ancient lava lakes, exposed on cliff walls of Alae and Makaopuhi craters, provide clues to future changes in the molten lakes.

Samples, collected by scaling the cliffs at rope-end, are being studied by the Observatory staff.

An immense amount has already been learned from the lake studies—properties of the molten lava, rate and temperature of solidification, chemical changes during solidification and during cooling of the solid lava, rates of thermal contraction, and composition of gases given off. Much more remains to be learned, and the studies are being pursued vigorously.

A variety of other geological and geophysical studies has been conducted in Hawaii by the staff of the Observatory, by Geological Survey scientists from other centers, and by scientists from universities and other federal agencies.

One of the most fundamental investigations is the geologic mapping and related microscopic and chemical studies of Hawaiian volcanoes, both active and extinct. Work by H. T. Stearns, G. A. Macdonald, H. A. Powers, and others has revealed a striking evolutionary progression in chemical composition and structure of the volcanoes. Briefly, each volcano begins as a low shield, built up by the repeated extrusion of many thin basalt flows. As the volcano grows larger, a caldera forms at the summit—the stage reached by Mauna Loa and Kilauea. Eruptions then become more infrequent; the lava changes in composition to alkali basalt, and is erupted as cinders, ash, and viscous flows that fill up the summit caldera; Mauna Kea is in this stage. Still later, small eruptions occur, scattered over the flanks of the volcano. These consist of viscous silica-rich domes and basaltic cinder cones and flows, rich in alkalies but poor in silica. The processes leading to this chemical evolution of the lavas are one of the major remaining problems. There is even considerable controversy over where the changes might take place—whether in the magma chambers within the volcanoes, or far below in the mantle at the site of magma generation.

A seismic refraction program on the island of Hawaii recently was aimed at gaining a better knowledge of the structure of the crust and mantle beneath the volcanoes. Seismic waves from explosives detonated offshore from a United States Coast Guard ship were recorded by portable arrays of seismographs along the highway that encircles the island. Analysis of the records at the Observatory, together with earlier studies of distant earthquakes, indicates that the Moho, the discontinuity between mantle and crust, is at a depth of about nine miles beneath sea level and that the crust is made up of layers that vary considerably in depth across the island. Other information on the structure of the crust has been obtained from measurements of gravity and from aerial magnetic surveys. As a result we know that dense, highly magnetic rock occurs at shallow depths beneath the summits and rift zones of Mauna Loa and Kilauea. The distribution of these rocks beneath Kilauea is being studied in more detail by use of a portable array made up of twelve seismometers that record on magnetic tape in a special instrument truck. Delays in arrival times of earthquake waves across the array will permit the mapping of many features of the underground structure and, hopefully, will aid in outlining the magma chamber.

Infrared aerial photographic surveys made during 1962 introduced a new approach to determining surface temperatures on Kilauea Volcano. The surveys show areas of contrasting surface temperatures, and reveal hot areas and steaming cracks on the volcano and cold springs along the coastline. Repeated infrared surveys may provide a way to monitor existing hot spots and disclose new hot areas; thus they might give evidence of increased heat flow preceding an eruption.

Co-operative studies with both foreign and domestic groups have been the rule at the Observatory since it was founded. In July, 1963, the Volcano Observatory became the site of the first U.S.-Japan Cooperative Science Program, sponsored by the National Science Foundation. A five-man team of Japanese earth scientists and technicians joined the Geological Survey staff to make special studies of Kilauea. They installed a closely spaced network of seismographs in the summit area (a network similar to those being used on volcanoes in Japan) and engaged in many joint studies with the Observatory staff.

The Japanese group was greeted by an outburst of seismic activity at the volcano, accompanied by the movement of approximately ten millio cubic yards of magma from the unde ground reservoir out into the uppe part of the east rift zone of Kilauea This was followed by extensive crac ing and faulting in the rift zone. A cording to reports from the Observa tory, "several earthquakes occurre per minute, and residents of the vo cano area were kept awake all nigl by constant shaking of the ground. During the rest of the six-month vis of the Japanese, Kilauea put on an e ceptional display of activity—anoth volcanic collapse, two eruptions, an several swarms of earthquakes.

The meeting served to bring t gether the experience and expe knowledge of two groups working o the same problems in quite differe volcanic environments. Mauna Lc and Kilauea are examples of basalt

Sulphur-topped cinder cone, remnant of spectacular 1959-60 eruption, rises above the rim of Kilauea Iki Volcano.

ıield volcanoes that quietly extrude reat volumes of fluid lava. The volınoes of Japan, like those of the acific margin of North America, ınge from basaltic volcanoes, similar › Kilauea and Mauna Loa, to andesic and dacitic volcanoes; these ex·ude much more viscous lava higher ı silica and alkalies and lower in magesia. Some of these eruptions consist f a slow extrusion of a nearly solid lug, like that which rose from Showaıinzan in Hokkaido during the early 940's. Many eruptions, however, are ıore violent, and vast amounts of both ew and old lava are thrown out as sh, devastating large areas. The coperative program allowed the Japaese scientists a chance to compare the olcanic behavior of Kilauea with that f volcanoes of contrasting composion in Japan and also to compare their techniques and theories with those of the Observatory staff. Similar studies are now being carried out in Japan, with U.S. teams working with Japanese scientists.

The Hawaiian Volcano Observatory has always served as a training ground for volcanologists—both domestic and foreign. In recent years men from Costa Rica and the Philippines have studied there, and volcanologists from all over the world make a point of stopping for at least a brief visit on their way across the Pacific Ocean. The Geological Survey has built its own cadre of trained volcanologists by rotating men in and out of the Observatory on short-term assignments. One of these was sent to help the Costa Rica government after the Irazú eruption in 1964, and in September, 1965, another was rushed to the aid of the Philippine government during the disastrous Taal eruption. These trained men will be invaluable when we turn to the task of monitoring the dormant volcanoes of our own Pacific Northwest—the majestic cones of Shasta, Hood, and Rainier, which some day may, like ancient Mt. Mazama in Oregon, erupt with devastating violence.

In the future as in the past, the men on the rim of Kilauea Crater at the Hawaiian Volcano Observatory will record the earthquakes, tilt, and temperature of Hawaii's volcanoes. Such data will provide a better basis for predicting volcanic activity and help unravel the causes and mechanisms of eruptions, determine the origin of magmas and the mechanics of their differentiation, and define the structures of the volcanoes and that of the underlying crust and mantle.

Sterile Flies Usec

Enemy of olives subjecte

By Dale Whitney

A large-scale experimental project aimed at eradication of the dacus fly is under way in the olive groves of Greece. If it is successful, it will mark another significant advance in the scientific control of fruit flies, and will point the way toward important economic relief for olive regions.

Because of these broad implications, Greek researchers have been joined in the project by the International Atomic Energy Agency, the U.S. Department of Agriculture, the U.S. Atomic Energy Commission, and entomologists from several other countries.

Atomic energy people are involved because radioisotopes will be used in the experiment to sterilize vast quantities of dacus flies. The Department of Agriculture has already eradicated tropical fruit flies on a few small western Pacific islands with releases of sterile flies, but is participating in the Greek studies because dacus fly control may become important to protect the California olives (as yet not infested).

There is a threefold basis for the experimental campaign against the olive fly (*Dacus oleae* of the family Tephritidae). (1) Entomologists believe that they can outproduce nature in propagating the olive-destroying insects. (2) By irradiation from radioisotopes at the pupal stage, the dacus males raised in captivity can be made sterile without critical loss of their urge or capacity to mate. No radiation is transmitted to the sterilized flies from the low-intensity gamma-ray source to which the pupae are exposed. (3) When sterilized males, in numbers ten to fifty or more times the number of free dacus males, are released in infested areas, they will dominate the breeding activity overwhelmingly; therefore most of the eggs laid by the free (normal) dacus females will not hatch, and in a few generations, with releases of sterile dacus flies continuing each week at the same overwhelming rate, the insects will be wiped out.

This threefold theory was conceived and demonstrated by E. F. Knipling, Director of the Department of Agriculture's Entomology Research Division. It has worked before, in the late 1950's, with dramatic success. By its application, the screw-worm fly, *Cochliomyia hominivorax* (Coquerel), was

to Combat Dacus

o radioisotope technique

PROLIFIC OLIVE FLY, *Dacus oleae*, here greatly enlarged, is actually about half the size of the housefly.

eradicated first from Curaçao in the Netherlands Antilles (NATURAL HISTORY, May, 1955) and then from Florida and most of the southwestern United States. Department of Agriculture entomologists had developed the technique and applied it on Curaçao as a small-scale prelude to the larger areas in the United States.

Besides extending the method to the western Pacific, the Department of Agriculture has found in Hawaii that the technique appears to be promising for Mediterranean fruit fly eradication; tests have also been made in Costa Rica with the participation of several Central American countries. The method also works on the Mexican fruit fly.

But the greatest triumph of the technique remains its victory over the screw-worm fly, a scourge of livestock. The female screw-worm fly lays eggs in an open wound of an animal. Larvae feed on the living flesh, causing severe injury and, quite often, death.

Use of the sterile-male method, when finally attempted on a large scale in Florida in 1958 and 1959, completely eliminated the screw-worm fly from the southeast in fewer than eighteen months. To achieve this success, the Department of Agriculture and the Florida Livestock Board, in a joint program, released by aircraft seventy million sterile flies per week at the peak —and more than three billion during the eighteen months—over a 70,000- to 80,000-square-mile area of Florida and parts of Georgia and Alabama. All the sterilized insects were bred and raised in captivity, in a tremendous "fly factory" housed in a former aircraft hangar. Releases of sterile screw-worm flies from a fly-production and -sterilization unit with even greater capacity at Mission, Texas, have accomplished equally phenomenal results in the Southwest.

Spectacular as was this victory over an insect pest—achieved more quickly than with pesticides, and without the potential danger of ecological side effects—it has not been easy to emulate.

Some of the most important work is the experimentation in Greece to try to get rid of *Dacus oleae*. But the problem is more complex than was that of the screw-worm fly, the Pacific fruit fly, and the Mexican fruit fly, for reasons involving the dacus fly's life

Life History of the Dacus Fly

Female injects eggs, with the pointed ovipositor in her rear, into a growing olive. She deposits about 300 eggs.

Green olives are preferred for her egg laying. Size comparison of olive and female dacus fly is shown here.

cycle. Just to test the sterile-male method on an island off Greece—one much smaller than Curaçao—will require captive-fly breeding on a large scale. In the Curaçao screw-worm experiment, about 120,000 sterilized screw-worm flies were released per week. Entomologists have computed that the requirement on the tiny Greek isle will be ten million sterilized male dacus flies per week.

Basically, the cause of this difference is the far greater abundance of the dacus fly. It is estimated that there were about forty screw-worm females per square mile on Curaçao up to the time of the successful eradication test there. In infested areas of Greece there are as many as 50,000 dacus females per square mile at the height of the breeding season.

One of the main reasons for this greater abundance is the easier supply of food available to dacus larvae than to screw-worm larvae.

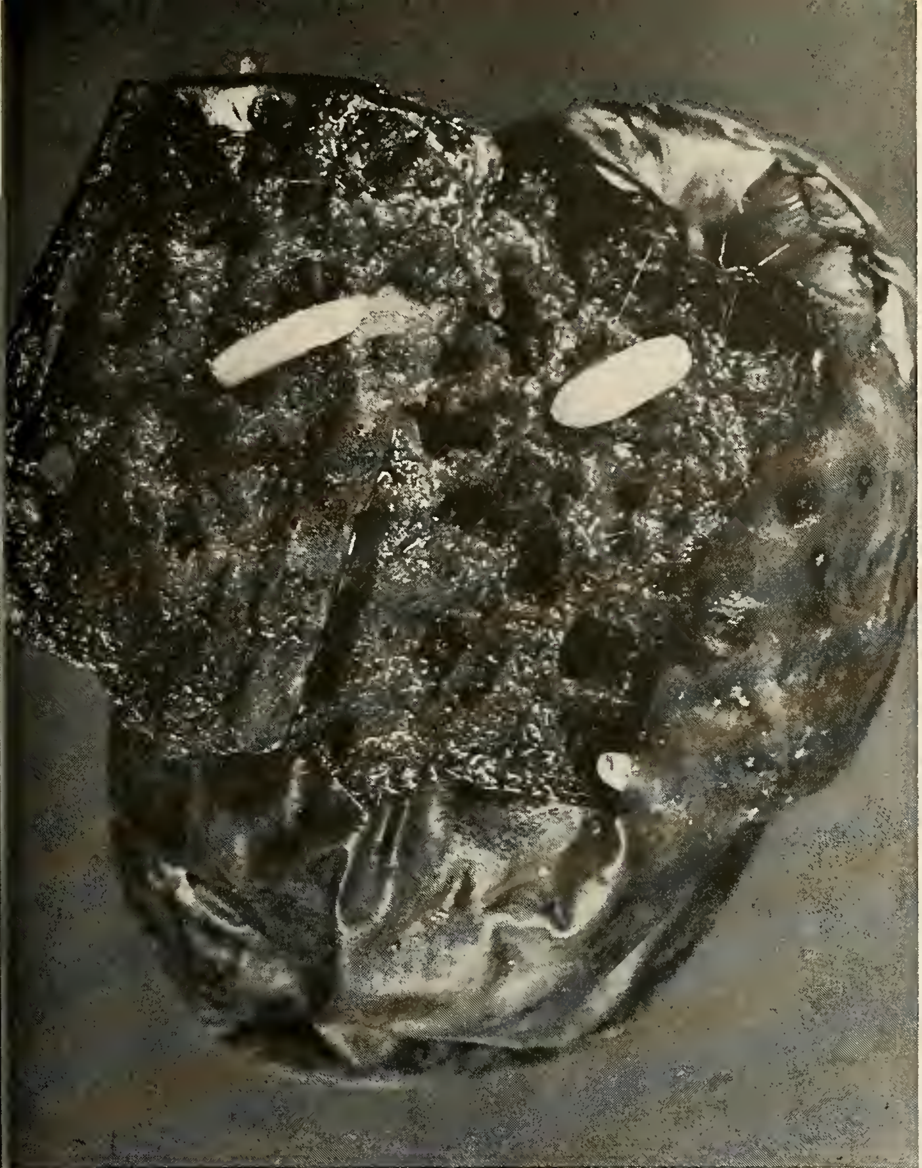
To produce young, the screw-worm fly female must find a mammal's wound in which to lay its eggs; even in livestock country, she may live out her life span without finding such a location where she can deposit her eggs and where the larvae, when they hatch, will have their necessary diet of flesh.

On the other hand, the female dacus flies have an abundance of locations in which to lay their eggs. Every olive is a potential and accessible place, and when the eggs hatch, the olive provides a ready diet for the dacus larvae. They, in turn, will severely damage or ruin the fruit.

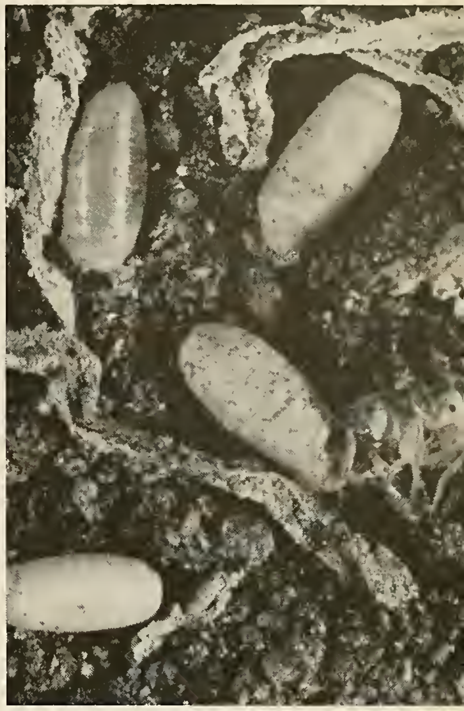
The female dacus fly is ready to mate two to four days after emerging from the pupa (the male is ready to mate at once), and can begin to deposit her eggs in another four to five days, or up to twelve days in winter.

She deposits each of her approximately three hundred eggs one at a time, and often each in a different olive. This takes her ten to twenty days, depending on the ripeness of the olives; she prefers green fruit, but it is firmer and injection takes longer.

The eggs hatch in about four days, and the subsequent larval stage lasts ten to fifteen days in summer or fall, and two to several months in the winter. The larval and pupal stages may take place entirely in the olive, or, in



Larvae have hatched from eggs and are feeding on a ripe olive, *above*, in which the dacus flies also lay eggs.



Pupae develop in the olive or, as is the case above, in the ground to which dacus fly larvae may drop and burrow.

When dacus emerges from pupa, male is ready to mate immediately, and the female will be ready in two-four days.

the winter, the larvae may drop to the ground, burrow into the earth, and wait until warmer weather before metamorphosis.

Thus, the life cycle of the dacus fly can be rapid. In warm weather in Greece, the whole period from egg to adult may be as short as nineteen days. In colder weather this process slows down considerably. The result is three to five generations per year, or more.

To combat such a prolific insect is not easy. Transferring the sterile-male technique from the screw-worm, and from its successful use on some other fruit flies, to the *Dacus oleae* poses three main challenges to the researchers: gathering the precise facts of life, propagation, and dispersal of the dacus fly; discovering a method of sterilizing dacus pupae while still leav-

ing the resultant males sexually competitive and sexually alluring to the females; and developing ways to raise vast numbers of flies in captivity.

Insecticides have been used in research into the numbers of dacus flies. On the island of Crete in 1962, a bad year for dacus, bodies of 556 adult flies were collected on one olive tree an hour and a half after spraying. Such large infestations, plus rapid and prolific reproduction of the dacus, probably indicate that a higher ratio of sterilized males to wild females will be required for eradication than was the case with the screw-worm. The hope is that a starting ratio of ten to one will be adequate to achieve the elimination of the dacus in test areas in five generations, or about a year. If the initial release rate is sufficient to reduce the natural population, each subsequent release of the same number of flies will result in a higher and higher ratio of sterile to fertile flies, thereby accelerating the effects of the sterile flies. A much higher starting ratio may be required, however, if the flies are damaged by radiation treatment as were the fruit flies in western Pacific tests.

Another aspect of the research effort is to learn the proper methods of sterilizing the dacus pupae. One of the toughest problems is to attain the exact amount of gamma irradiation necessary for 100 per cent sterilization, with minimum casualties of flies and—most important—without seriously impairing the mating habits of the treated male or his appeal to the wild females.

In small-scale laboratory experiments, Greek entomologists believe they have attained satisfactory sterilization results. It remains to be seen, however, whether their methods will work well in mass production of sterilized flies for use in the field.

Mass breeding and raising of the flies in captivity in the enormous quantities that are needed is the third big problem of the scientists. A steady supply of millions and even billions of healthy flies is needed.

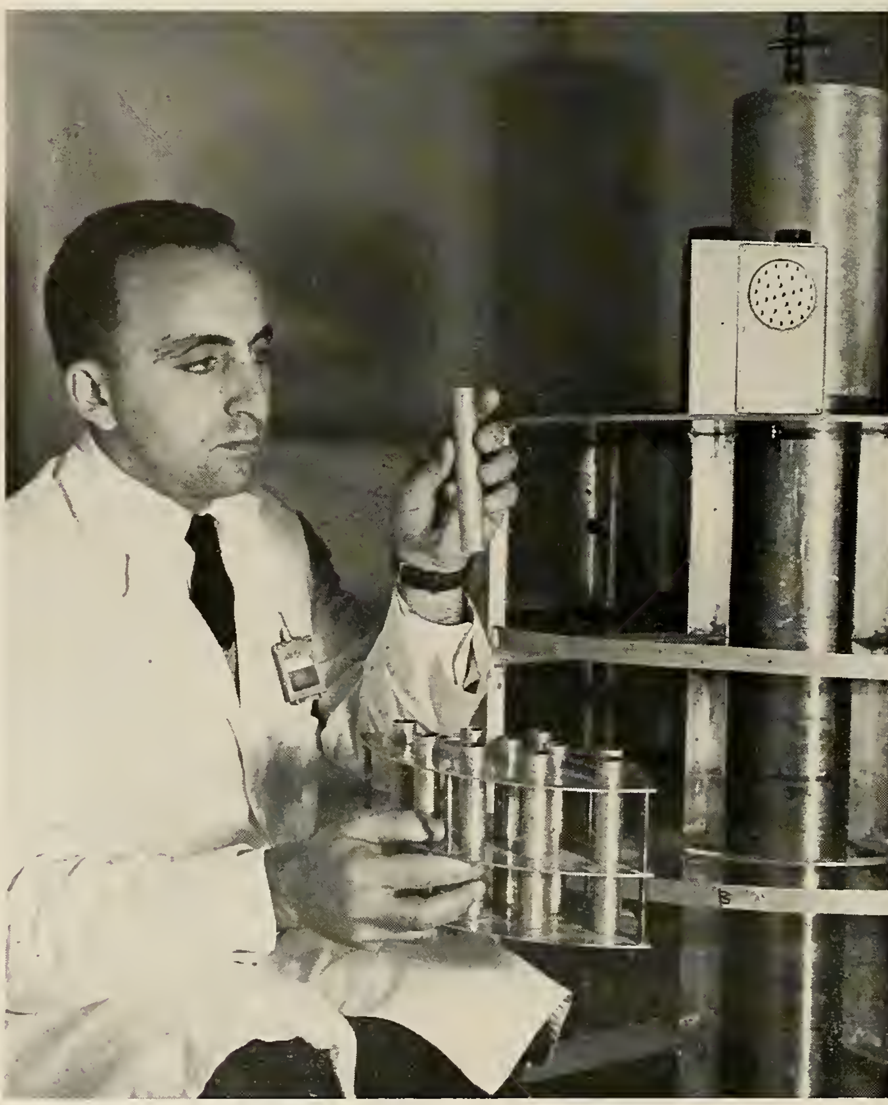
One of the critical needs has been to develop a satisfactory feed for the larvae. The first intensive research on this problem was carried on by Dr. K. S. Hagen, Associate Entomologist at the University of California, who was sent to Greece as an International Atomic Energy Agency expert in 1961-63 to work with Greek scientists. Finally, a formula of more than ten components—including carrots, proteins, olive oil, and yeast—was developed. Although apparently not the final answer, it has been effective in the raising of several generations of dacus flies with good longevity, vitality, and sexual competitiveness.

There was also the problem of finding a medium in which captive, fertile female dacus flies would deposit their eggs. Obviously, because of the vast supply of flies that would be needed, a substitute for olives had to be found. What has emerged from much study are paraffin domes into which the females will inject their eggs. The eggs are then removed to hatch.

The overriding aspect of the whole problem, of course, is to convert these laboratory-developed techniques into economical mass production.

Among scientists who are participating as consultants in the efforts to solve this and other problems of massive-scale production of sterile olive flies are L. D. Christenson and Loren F. Steiner of the Entomology Research Division of the U. S. Department of Agriculture. They have visited Greece to work with experts of that country's Benaki Phytopathological Research Institute, Ministry of Agriculture, Superior School of Agriculture, and Democratis Atomic Energy Research Center, and with the international and U. S. atomic energy agencies.

Perfection of the sterile-male technique is only one—but a highly important—phase of their comprehensive attack on the olive fly. Their other approaches to olive-fly control have also led to investigations of attractants for trapping the flies, chemosterilants that may take the place of irradiation, and the administration of insecticides in small amounts mixed with baits appealing to the flies.

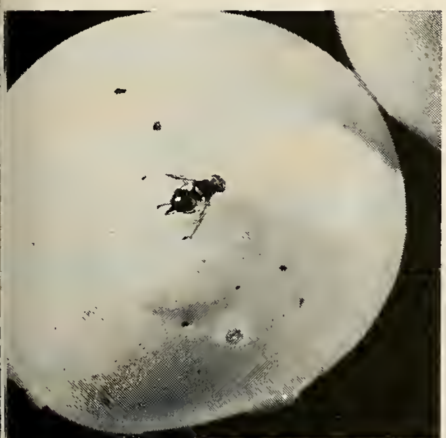


Irradiation research is performed on the dacus fly near Athens, Greece, by Dr. M. E. Tzanakakis. Here pupae are subjected to radioactive cobalt.

Substantial achievement in control of the dacus fly by the sterile-male method will have implications for a wide Mediterranean area.

The dacus fly is one of the world's most devastating insect pests. It takes a toll of nearly a third of all olives produced on countless trees in the Mediterranean area. In some sections, in bad years the loss has run to 80 per cent of the crop. Greece seemed appropriate for the present control experiment because many areas of that country are so greatly dependent on the success of the olive crop.

If success crowns the effort in Greece, it is certain that researchers and practitioners will attempt to spread their experience to other areas—and to other insect pests. This could represent one of the great achievements of modern entomological research and peaceful application of atomic science.



Paraffin dome supplants the olive as a medium into which flies inject eggs.

Eggs are removed from dome into glass dish. Larvae feed on a special formula.

Adult females, produced in captivity, are fed from moistened filter paper.

Part II:

Locomotion Without Limbs

Smooth surfaces pose special problems

By Carl Gans

In Part I of this article (February, 1966), we explored some of the reasons why lateral undulatory locomotion provides an obviously successful method of limbless progression and discussed some of its biomechanical aspects. Such locomotion is simple and is derived from a variant of an ancestral pattern, the activation of which appears already to have been coded into the animal's central nervous system. It apparently incorporates a feedback from the forming loops so that their shape is continuously (and automatically?) affected by local conditions and, more specifically, by the nature of the points against which the propulsive force is directed. It permits the traversing of a wide variety of terrain, often at high speed, and it quickly converts to a method that is effective in water.

Yet with all its advantages, this means of locomotion has been shown to be ineffective for traversing smooth, even surfaces—areas that lack the vertical irregularities against which the moving loops may exert their force. It has also been found to be unsuitable for traversing smooth, parallel-sided tunnels. Beyond this, it requires a minimum path width; thus it cannot be used in a tunnel whose diameter is so narrow as to make the forming of loops ineffective. Finally, there is the decrease in locomotor efficiency in animals that have been exposed to other selective influences that make a shorter and stouter body more effective. All of these factors have established selective advantages for modification of the undulatory pattern, or for different patterns that permit more effective locomotion under these specialized circumstances.

Such different patterns have, surprisingly, been developed by only two groups—snakes and amphisbaenids. In both cases they involve the utilization of friction, which is here used to advantage for the first time in limbless locomotion. The propulsive force is in each case transmitted to the substratum through an area of the animal's body that remains in stationary contact with the ground. The moving portions of the animal are, in contrast, lifted either completely or partially off the ground. This reduction of the force that presses together surfaces in sliding contact means a simultaneous increase of the force loading the zone that is in stationary contact. Since the coefficient of sliding friction is much less than that of static friction, the reduction of the force required to slide the animal's moving portion is coupled with a simultaneous increase in the force that the animal may exert backward against the ground.

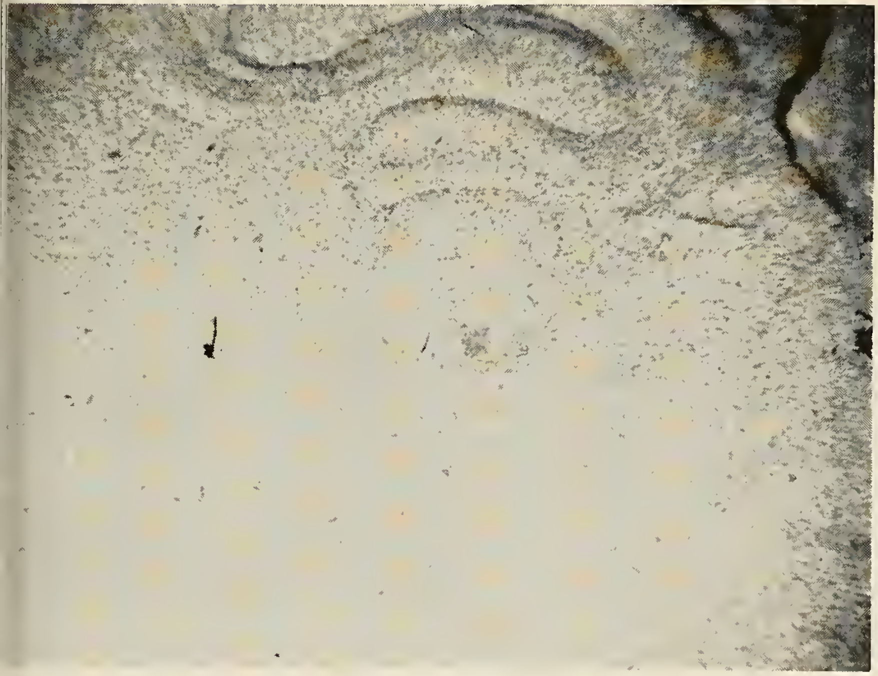
The principles are most clearly demonstrated by the so-called concertina method. In this the animal always has a coil (or coils) of its body in stationary contact with the ground. Only the parts before and after (or between) the stationary region(s) are in motion. In the simplest case, an animal of weight F_W rests in a simple coil on a smooth and flat surface; the coefficient of static friction between the surface and the snake is c. Any attempt by the animal to stretch out or push forward its head and anterior end requires that a force be exerted upon these and that an equal and opposite force act upon the remainder of its body. This opposite force will tend to move the stationary portion of the body in a direction opposite to that in which the head is moving.

Slippage will be avoided as long as the force inducing movement of the head is less than $F_W \times c$, that is, the static friction at which movement would occur. As an increasing portion of the anterior end starts to move, part of the animal's weight will no longer contribute to the production of this potential static friction; it will simultaneously induce the negative effect of sliding friction. There is thus a limitation of the distance that may be moved by a single such cycle. As the slipping point is approached, the animal places its head and neck in stationary contact with the ground, and the portion of the body between this and the remnant of the original coil is now pulled as well as pushed. When the reservoir of static friction induced by this new coil is no longer needed to counteract the sliding friction on the posterior portion of the body, the animal can move its head and neck forward to the next stationary position.

The concertina pattern has been modified and adapted in a variety of ways that indicate its flexibility and importance. It requires only minimal changes in nervous control and no changes in the locomotor apparatus. Its greatest advantage is that the force inducing the potential static friction may be increased by muscular action beyond the force that is induced by the animal's weight.

A snake may exert such additional force by throwing the body into curves and pressing them inward or outward, as, for instance, against the walls of a straight tunnel. The method permits the snake to traverse such a straight-sided tunnel because there is no longer any need for pushing the loops of the body against anteriorly facing surfaces. The force is exerted at right angles to the wall and to the probable direction of locomotion.

Several variants of the method permit snakes to climb. In one, the snake



Control of musculature permits some species to have specialized behavior patterns. For example, each part of trunk of this small viper of Pakistan sweeps from side to side, digging trench into sand, allowing the body to sink down vertically. Waves pass backward, but movement is from back to front. Head sinks last, and only a coiled outline remains in mounded sand.

constricts a branch and then uses the potential static friction of the contact area to counteract the force required to lift the rest of the body. When the anterior end has moved to a point farther up the branch or stem, it executes a half hitch and again induces potential static friction against which the remainder of the body may be lifted. The method reminds one of the way in which an athlete climbs a vertical pole.

When the bole of a straight tree has too great a diameter to permit the snake to throw a complete or partial loop around it, climbing requires additional specializations. Certain snakes can ascend even such trees by utilizing free edges of bark breaks or similar irregularities. The snake treats these as if they were sides of a shallow channel that curves up the trunk. Movement within such a channel is by the concertina method, although the shifts are often for only short portions of the body and the motion may proceed very slowly. Like a rock climber who finds it advantageous to wear boots in which the sole does not protrude beyond the level of the toe, so such a snake finds it advantageous to be able to exert the lateral force of its loops as close to its ventral surface as possible. This seems to be why many arboreal snakes have a sharp keel on each side of their ventral surface, giving them a cross section resembling a sugar loaf, rather than an oval.

A final application of the concertina principle is seen in certain burrowing snakes and amphisbaenids that have a pointed and often downward-curved caudal tip, which they dig into the ground or the wall of their tunnel and use as a brace. This, of course, increases the potential force that may be exerted to move the body forward or to push the head through the soil.

The energy consumption of animals utilizing these methods has never been measured. Theoretical considerations indicate that concertina movement would be slightly less effective than lateral undulatory movement, mainly because all parts of the body alternately accelerate and decelerate rather than move at a steady velocity (at least in one direction). The inefficiency increases as muscular force is utilized to increase the static friction potential. The method is thus one whose advantage must lie in permitting the animal to move across otherwise difficult terrain, rather than in its mechanical or energy-related effectiveness.

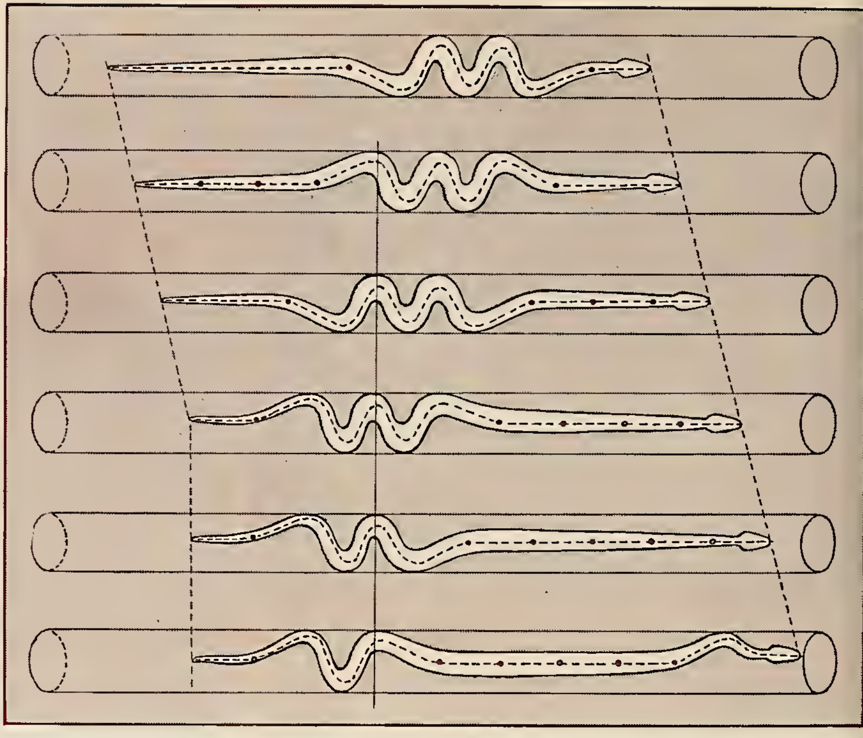
THE inefficiency of subjecting the animal's entire mass to cycles of positive and negative acceleration, from a zero velocity to that of travel and back again, is obvious. For instance, the energy absorbed during deceleration of the body must be expended on the ground rather than stored in some manner for the next acceleration cycle. Locomotor efficiency thus increases as greater fractions of the animal's mass are allowed to travel at a constant velocity. In such a system, the animal has reduced the mass of the portion that is intermittently in stationary contact with the ground; this reduced mass lessens the momentum required during the acceleration cycle. Of course, this is the solution found in various running (and flying) animals in which the accelerating portions of the appendages are extremely slender, as in antelopes and birds. Close to 80 per cent of the mass of some animals adapted for running retains a steady velocity during a run; the bodies move along a straight line, often without a marked rise and fall.

Certain groups of snakes, such as boas and vipers, and all amphisbaenids have utilized this principle in the development of rectilinear progression, a method so called because the animals can truly move in a straight line. Here the head and body may travel at a steady rate, because they have been liberated from tight connection with the skin. Such liberation is found in the ventral surface of snakes, but occurs around the entire circumference of amphisbaenids.

Portions of the loose skin are pulled forward by a series of anteriorly attached segmental muscles, and are there forced into stationary contact with the substratum. Several sections of the body will be in contact with the ground at any one time. During this movement the ribs do not change position relative to the vertebral column, as confirmed by windows cut in the snake's skin and X-ray movies of a snake traveling by the rectilinear method. The segmental muscles can, depending upon their arrangement, move the body backward as well as forward, and amphisbaenids have derived their name (*amphis* = on both ends, *baena* = to go) from their capacity to proceed backward down a tunnel.

The angles at which the various bundles of muscle pass from ribs and vertebrae to the several parts of the skin relate again to the mechanical effectiveness of the system; only the forces induced in parallel to the direction of motion will promote acceleration or sustain movement. Yet many limbless species have the anterior bundles placed at much greater angles to the surface of the ventral skin and, consequently, positioned less efficiently than the posteriorly directed bundles. The anterior bundles apparently pull the skin forward and out of contact with the substratum. The skin thus does not slide, and there is almost no sliding friction. This reduction of friction apparently compensates for the minor inefficiency when the same muscles fold the skin forward.

The points of stationary contact seem to move along the trunk from front to rear, although the fraction of the skin involved in these stationary connections changes constantly. Rectilinear locomotion is particularly effective for travel down a tunnel, as it is possible to install such a fixed site at a radial point of the circumference, and there to contact and pull against a portion of the tunnel's wall; this totally liberated skin presumably contributes to the success of amphisbaenids in the subterranean habitat.



Concertina movements allow snakes to traverse smooth surfaces and straight-sided tunnels. Part of body is always stationary on ground; snake can then apply enough force to ground to move front and rear parts forward.

Rectilinear locomotion is also of interest because it requires a specialization not immediately apparent. The need for liberating the skin is readily seen, but the method also provides the first locomotor movement in these groups that is activated by symmetrical, rather than staggered, waves of contraction. We know that certain fin movements are similarly symmetrical, and so are the jumping movements of frogs (NATURAL HISTORY, February, 1961). All of these occur in specialized forms, and here, again, is a topic whose meaning needs consideration.

This method, then, has solved the problem of continuous, relatively efficient traversing of smooth, even surfaces and straight, narrow tunnels. It has achieved an incidental advantage because it will let a thick-bodied, short snake approach its prey in a straight

line without weaving motions. Yet its slow velocity is a definite limitation to rectilinear locomotion. A minimum time is required for the attainment of static friction between two surfaces, and an increase in the animal's velocity will increase the danger of a shift from static to sliding friction. Speedy travel appears to be a problem only in the open, as tunnel dwellers do not seem to have found rapid travel down an existing tunnel advantageous; in any case, we know of no limbless form that has achieved it.

A variety of snakes have, however, developed sidewinding, a drastically different method of locomotion—and in some ways a derivative of the concertina method—that is ideal for rapid traverses of smooth and even surfaces. Sidewinding is peculiar in many ways, not the least of which is that it may be more effective on soft sands than on a hard surface; the tendency of the sand grains to slip out from under the loaded zone turns out to be advantageous. Sidewinding is certainly a fast, if not the fastest, way for a snake to travel under these circumstances. This speed has led to a certain amount of confusion and, thus far, an absence of comparative studies. It is interesting that Walter Mosauer's description of the movement has turned out to be essentially correct, even though it was prepared thirty years ago without the aid of stroboscopically exposed pictures or other paraphernalia. His functional interpretations were, however, quite different from those now accepted.

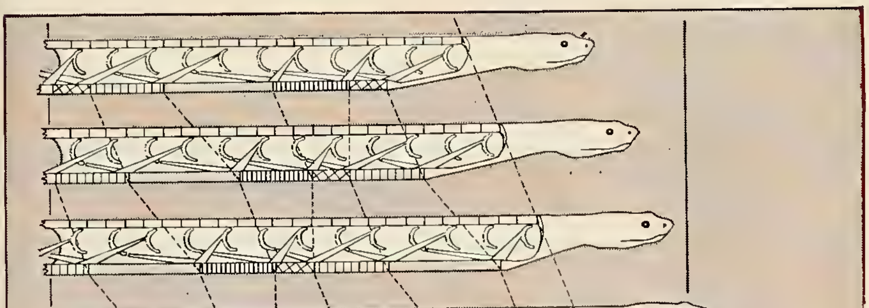
It is not the speed alone that makes sidewinding appear confusing to the viewer. There is the supplementary complication that the animal's axis does not point to the direction of motion; the head will generally appear in a lateral position, and some portion of the trunk appears to lead. A sidewinder's tracks also lack continuity. The trackway consists of a series of parallel lines each inclined at an angle to the direction of motion. Each of these impressions is approximately as long as was the specimen that produced them, and it can easily be seen that the snake occupied it with the head pointing *backward*. How can such tracks be produced, and why should sidewinding allow the snake to move at higher speeds than do the other methods?

The movement may be visualized most easily by assuming a snake at rest lying at an angle to the direction along which movement will take place. To start into the sidewinding sequence the snake will lift its head and anterior body off the ground and will then swing them forward through an angle. The lifting of the anterior end and its acceleration occur without a compensating shift of the snake's body as long as the forces applied are less than the static friction potential. Once the head has reached the new site, having advanced some distance from the previous track, it is arched downward. Only the head, but not the connecting loop, touches the ground, and the trackways show that considerable downward force is exerted (*see pages 40, 41*).

The neck immediately forms an anteriorly open, U-shaped bend, and the loop between the two parallel tracks starts to travel anteriorly as the snake's body moves from the old to the new position. Only the portion of the body within the loop moves at any one instant; those portions in contact with the tracks remain stationary. As soon as the potential static friction exceeds the amount required to lift and accelerate a single loop, the head may lift off the second track, swing anteriorly and move toward the site of a third track to start a new cycle.

Sidewinding has an inherent disadvantage—the animal's entire mass must be lifted off one track and transferred to the next by muscular action, and this must happen once each cycle. This suggests that lifting the loops too high may be disadvantageous, and it is perhaps also suggestive that various snakes that sidewind only occasionally and poorly seem to lift their loops much higher than do forms for which this is the characteristic method of movement. The excellent trackways obtained by letting an animal cross a piece of sooted cardboard or a surface strewn with fine sand show that the loops will occasionally touch the ground, particularly when the head is swinging to the next track.

There may well exist a kind of feedback that indicates to the snake the amount of sliding friction it may tolerate, or that strikes a balance between it and the static friction potential. In contrast, there are certain sands that pack into a solid mass when compressed, but whose surface particles roll under lateral forces and act almost like solid lubricants. This effect is well known to anyone who has ever tried to take a car around a fast turn while traveling on an unbanked loose-gravel road. A sophisticated control arrangement might permit the snake to compensate for surfaces with different coefficients of friction by raising or low-



In rectilinear locomotion, vertebrae and ribs are rigidly fixed. Muscles that attach ribs to skin alternately contract and relax. Those that pull the body forward lie at flat angle; others, at high angle, pull skin back and out of contact with ground, thus avoiding sliding friction on return movement.

ering the loops or by letting them rest more or less heavily upon the ground.

A sidewinding snake will also leave remarkably sharp markings of its ventral scales along the track, and when traveling on loose sand will push up a narrow, fringing ridge of sand on each side. This is because the forces tending to shift the body on the ground act at an angle to, rather than in parallel with, the individual track. When a snake is moving between three tracks (*see below*), the portion of its body on the second one will be acted upon by opposed forces directed along roughly parallel lines. Such pairs of opposed, parallel forces are known as couples, and induce tendencies for the structure to rotate about a point intermediate between them. Since the sites of force application move as the loops shift, so do the couples. The slight amount of movement actually induced would tend to shift the body from side to side rather than along its track.

Rattlesnake sidewinding on smooth surface is traveling straight upward to top of picture. Head and neck are lifted, but not placed for next move.

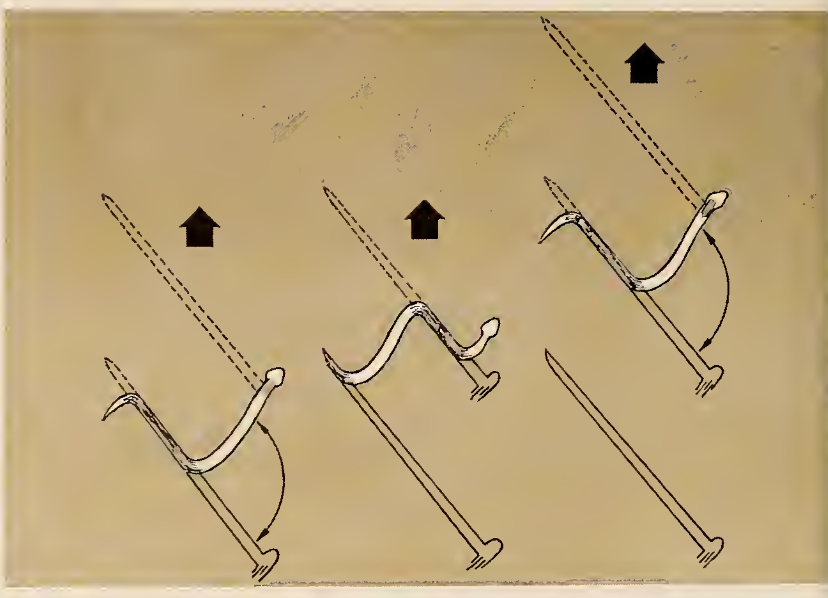
This movement appears to be responsible both for the ventral scale markings and the sand piling. The piled sand limits excursion by increasing the available resistance, and allows the trunk's ventral surface to return to the static condition. The slippage would be most likely when snakes moving at a high velocity temporarily exceed the potential static friction. Both the sand piling and the markedly greater coefficient of sliding friction at an angle to the long axis again suggest that a self-limiting device is involved.

Most of the species that make major use of sidewinding are forms of the desert or of sandy and rocky areas in which there are relatively large distances between hiding places. Species of such zones are exposed to predators when crossing from one sheltered spot to another. Speed, rather than locomotor efficiency, is the major factor seemingly selected for. Dr. Raymond B. Cowles of U.C.L.A. has recently reemphasized the speed possible with sidewinding movement, and has also suggested that sidewinding is of selective advantage to snakes that may have to cross stretches of hot sand when disturbed at midday. He feels that the lifted body affords less opportunity for heat gain by conduction.

The latter hypothesis, which could permit the metaphor that sidewinding may let a snake gallop or tiptoe across a hot surface, is appealing. Yet the rate of heat transfer is also a function of time, and sidewinding is certainly three times as fast as the fastest rectilinear movement. Furthermore, the body is out of contact with the ground just as much in the concertina, and possibly in the rectilinear, movements. So speed remains the most obvious advantage of sidewinding.

The methods of lateral undulation, concertina movement, rectilinear progression, and sidewinding are the four locomotor patterns generally discussed. This is because they are probably the most common methods of limbless movement, but they are far from being the only ones. Certain aquatic snakes have developed flattened, oarlike tails, which provide increased surface in the zone where the moment arm (distance from force application to fulcrum) is longest; this makes their swimming much more effective. Some East Indian species have devices for flattening their ventral surface into a concave surface. They launch themselves from trees and, by maintaining a fixed posture, glide rather than fall.

Certain short-bodied amphisbaenids have developed an emergency escape



In diagram of sidewinding progress dark parts of body are in contact with ground. Dashes show future pathway; arrows show direction of the motion.

mechanism in which they dig in their downward-curved tail while their body lies in an S-shaped curve. They then reverse the S by sudden muscular contraction, imparting enough energy to send the body flying forward a short distance. A series of these "jumps," or saltations, allows the animals to travel at an otherwise unattainable speed. All such devices represent specializations of often limited groups, and none of them is as widespread (successful) as the four major methods of limbless locomotion. Their interest lies mainly in giving an increased appreciation of the diverse paths along which forms may be moved by natural selection.

PERHAPS the most important thing that must be appreciated about the locomotor pattern of limbless forms, and the one that has probably been masked effectively by discussing and analyzing them under separate headings, is that the animals pay no attention to the biologist's carefully worked out schemes. They can, and one might almost say they generally do, utilize two or more methods simultaneously and with different portions of their body. Thus, swimming snakes can, when leaving the water, shift the anterior portion of their body either to lateral undulatory or to concertina movement and still "row" with their posterior portion.

When the anterior zone of a sidewinder reaches an area in which rocks make sidewinding ineffective, it may shift into rectilinear movement, although the posterior portion often continues the sidewinding motion. Careful analysis of snakes traversing broken ground has shown that they often use a combination of concertina and lateral undulatory movement. It thus becomes difficult to understand the pattern of progression unless there are devices for measuring the location and magnitude of the forces exerted by the animal.

Even when we have a record of the forces, and can see what the snake does, we have only answered the first questions. We do not know how the snake knows which method will be most effective. Nor do we know how an arboreal form handles the additional task of controlling slippage not only of the whole animal but of each portion of the moving and often elongate body. And, much more to the point, how does the snake keep track of the requirements of the different zones along the length of its body? "Know" is clearly the wrong word to use. In each case there must be serially arranged, semiautomatic systems or devices for reporting the existence of fixed sites and for monitoring the pressure that will make a particular deflection take place.

It is clear that these devices are similar to, although perhaps more complex than, those already mentioned in discussing the animal's control of a single locomotor pattern. Feed-back circuits are involved between the several levels of receptors and the muscles. These have been shown to involve the animal's central nervous systems, both on the spinal and the cephalic levels. Their analysis is properly a problem in neurophysiology.

The foregoing analysis has suggested functional reasons for the development of the major methods of limbless locomotion. To state the problem differently, the analysis has brought out a sequence of possible selective advantages that could, and probably did, trigger the development of the several markedly different methods of limbless locomotion. The establishment of such a sequence of advantages represents one use of the functional approach to anatomy.

The operational answers provided by functional morphology, then, serve mainly to provide us with the basis for asking more specific and possibly more sophisticated questions at the next level of functional explanation.

Hooks at track ends are made by head of sidewinding snake. Depth of track and side ridges show slippage during shift from static to sliding friction.

Oceanside and Inland Faces of Florida

From the swamps of the south to the forests of the north, the Florida peninsula harbors an abundance of natural wonders. The home of alligators and ibis, citrus groves and cypresses, and islands of pine and palm, the state is a land of contrasts. It has 30,000 lakes, 1,200 miles of coastline, and its entire southern tip constitutes a subtropical wilderness. Some of the world's rarest birds nest in Everglades National Park, and its marshy waters are America's last refuge for many animals. These pictures were entries in a Florida photography contest.

Desolate sand dunes of the Gulf Coast contrast with the lush vegetation of a swamp, right. Exotic birds like the anhinga flourish in protected areas.

Marion Creek, in central Florida, is part of a network of inland waterways.

Stiltlike mangroves along the shore of Biscayne Bay help stabilize the sand.

SKY REPORTER

Comets, studied for many years, remain an enigma to scientists.

By Thomas D. Nicholson

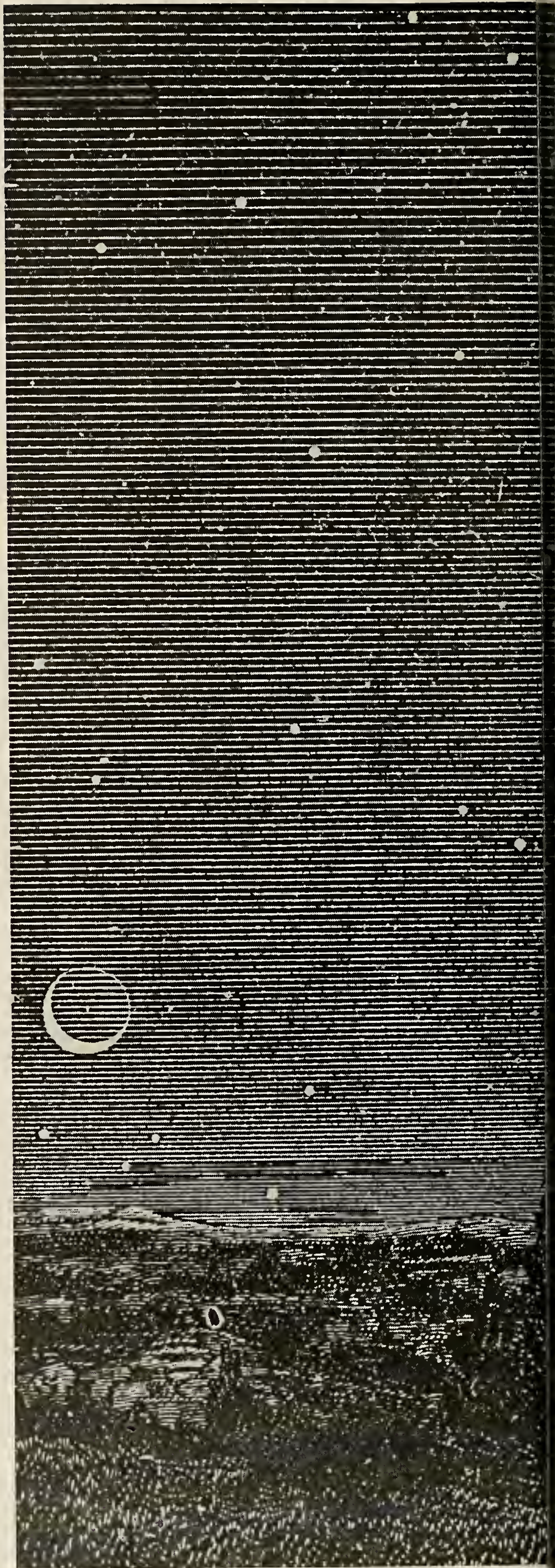
As did many other famous comets, Ikeya-Seki, Comet 1965f, which I described in last month's "Sky Reporter," became a much more interesting object after it had passed around the sun and began moving out into the far reaches of the solar system again. After October 21, when it passed through perihelion, reports began coming in that it had been seen in daylight; that it had developed a long, brilliant tail; and, finally, that it showed evidence of breaking up.

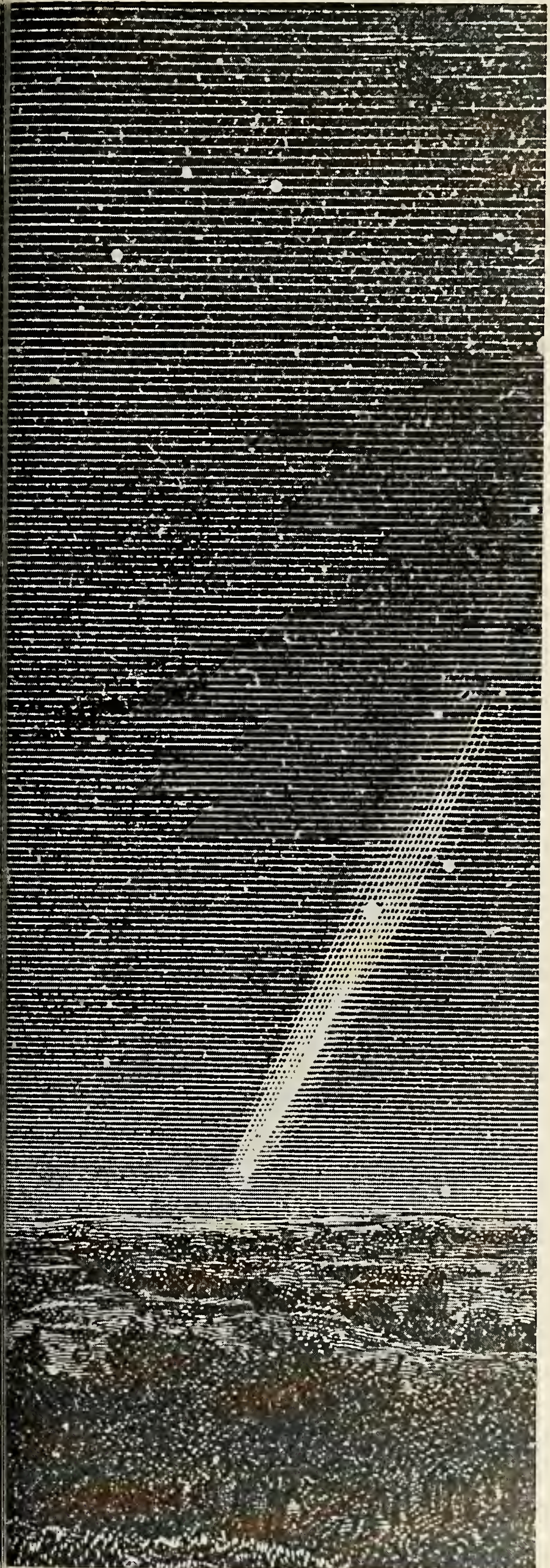
Dr. Elizabeth Roemer, of the U.S. Naval Observatory Station at Flagstaff, Arizona, described the comet as a naked-eye object throughout the day of October 20 and for most of October 21, until atmospheric haze began to interfere. At 4:30 P.M., MST, on October 20, she reported seeing a sharply curved tail, about 2 degrees in length, when the comet was within one solar diameter of the edge of the sun. She said she had the impression that the comet's head was comparable in brightness to the visible surface of the sun during the afternoon of the 20th.

Numerous persons throughout the United States saw the long, bright tail that Comet Ikeya-Seki developed after perihelion. Easily visible as it rose in the dawn sky during late October and early November, the tail grew in length until its arc was about 25 degrees.

Another link in the kinship between Comet Ikeya-Seki and its famous predecessor, the Great Comet of 1882, was discovered during early November. After Comet 1882 II passed around the sun, its nucleus was observed to break up into five or six distinct, starlike points, strung out in line, prompting the nickname "The String of Pearls Comet." Astronomers wanted to find out if the same kind of disruption would take place when Comet Ikeya-Seki passed a similar distance from the sun. Apparently it did. On November 4 and 5, Mr. Howard Pohn, of the U.S. Geological Survey Astrogeology Station at Flagstaff, Arizona, observed that the nucleus of Comet Ikeya-Seki had broken into two or, possibly, three distinct parts, strung out through the comet's head. Confirming observations came from observatories in South Africa, California, and Japan.

This comet's similarity in orbit and behavior to those of other members of this sun-grazing family again raises the question of the origin of this family in particular and of comets in general. Comets may be described as large collections of meteoroid particles (small chunks of stony or metallic material) bound together by a slushy envelope of frozen gases—generally molecular forms of hydrogen, oxygen, nitrogen, and carbon, and their compounds. Their orbits are usually elongated ellipses, so that their distance from the sun varies considerably. When far from the sun,





they are inactive, cold, dark objects, since they receive little solar energy. And, since they must obey all the laws of orbital motion, they spend most of their time traveling slowly through the outer parts of their orbits. Thus, a comet is observable from earth only when it approaches close to the sun so that it brightens, develops a tail, and perhaps breaks up into several parts.

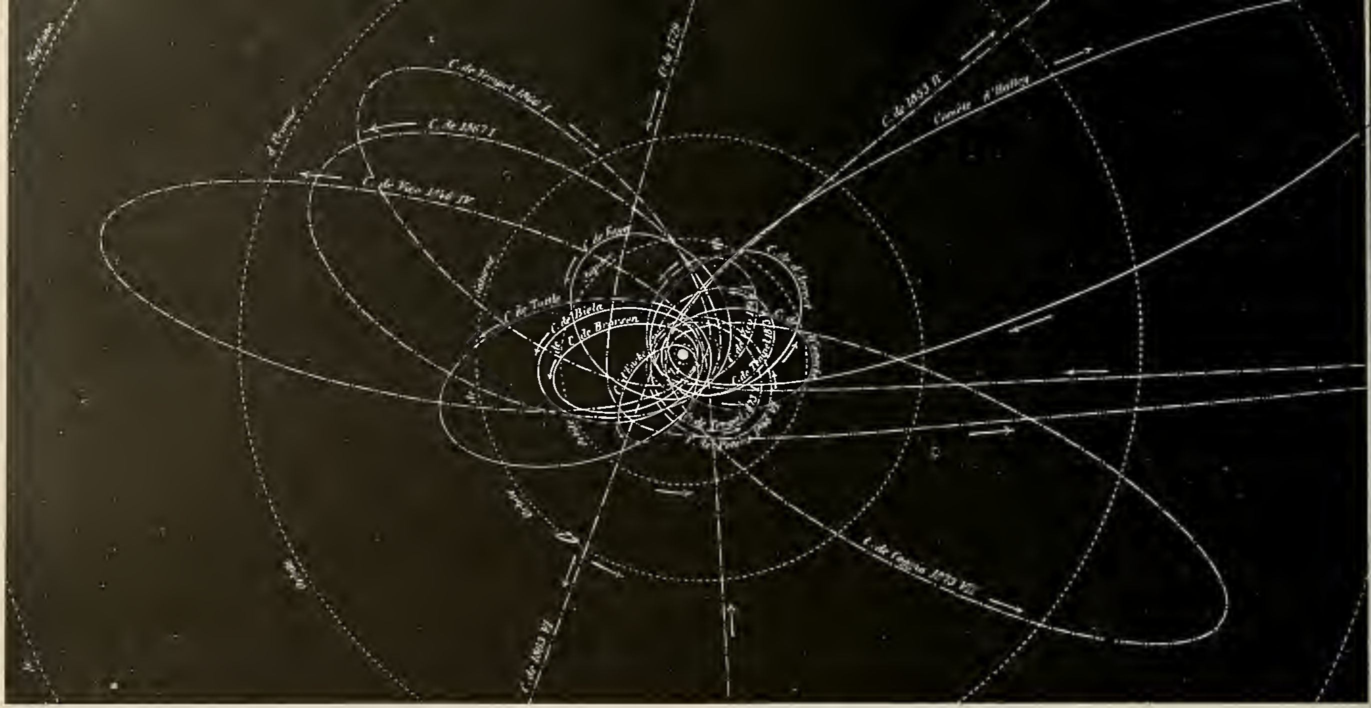
At one time, comets were thought to be rare. Until the eighteenth century, the only ones known were those that became bright enough to be seen readily by the unaided eye. With the invention of the telescope, discoveries increased. Since 1800, improved observing instruments and techniques have sharply increased both the number discovered and the rediscoveries of periodic comets. In the decade between 1950 and 1960, for example, some 80 were observed, more than were seen during the entire eighteenth century, although many of these were previously known periodic comets. At the present rate, we may expect to see 300 to 400 new ones in every century.

Until the eighteenth century, it was believed that each comet was a new one, making a single appearance in earth's sky and then disappearing forever. The English astronomer Edmund Halley (1656-1742) discovered that the bright comets of 1531, 1607, and 1682 had similar orbits. He stated that these were actually the same object returning to the sun's vicinity every 75 or 76 years, and predicted that it would return again in about 1758. It did, and in his honor, even though he did not live to see its reappearance, it was named Halley's comet. It remains the most famous member of the comet family, with a history of observation dating back to 240 B.C., and continuing to 1910. It is expected to return sometime in 1985 or 1986.

Today, there are close to 200 known comets whose orbits are elliptical. Their periods vary considerably, from 3.3 years (for Encke's comet, the one of shortest known period) to many thousands of years. In the periodic group are several families of short-period comets whose periods and orbits indicate that they have some physical relationship with the major planets. Some 66 comets with periods of less than 10 years belong to Jupiter's family. Saturn's family contains 5 with periods of 12 to 20 years; Uranus controls 6 comets with periods of 27 to 50 years: and Neptune's family contains 10 (including Halley's comet) with periods of from 50 to 100 years. Aside from those associated with the planets, all others have periods in excess of 100 years.

The great majority of known comets travel so rapidly in the sun's vicinity that their orbits appear to be parabolic or near parabolic. (This type of orbit is between an elongated ellipse, in which the comet would return again, and a hyperbola, in which a comet would escape from the sun.) It is unlikely, however, that all these are actually traveling in parabolic orbits. Astronomers are generally agreed that most comets are actually moving in very long-period elliptical orbits that resemble parabolic orbits only in the sun's vicinity. It is also agreed that these comets will return to the sun again, but only after long intervals—millions of years in some cases.

Great Comet, as it appeared on October 9, 1882, is shown in wood engraving. Besides spectacular night display, comet was clearly seen near the sun at noon on four successive days.



In diagram, inner orbits are representative of short-period comets (mostly of the family of Jupiter) that appear every 3.3 to 15 years. Large eliptical orbits represent the paths of comets that return every 100 to 1,000 years. The orbits that appear as incomplete lines are those of the parabolic comets that make a single visit and are never seen again.

Each time a comet passes through perihelion, it must lose some of its material. Although there is no absolute knowledge of how much material a comet possesses, it is clear that those which come close enough to the sun to develop a coma and a tail must lose an appreciable amount of their material. It has been estimated that most known periodic comets can survive only about 100 trips around the sun before they disintegrate completely. Halley's comet, therefore, might have a total lifetime of less than 7,500 years in its present orbit. In the case of a comet in a near-parabolic orbit, with a period in the order of a million years, the expected lifetime might be about 100,000,000 years—a relatively short interval in the cosmic time scale.

If we accept the fact that comets are transient objects, we must somehow account for the fact that we continue to see them today in a solar system that is at least five billion years old. Several possibilities present themselves. It may be that the solar system is continually being supplied with comets from interstellar space. In the observed velocities of comets as they pass near the sun there is no evidence that they have reached us on interstellar orbits. It may be that comets are continually being formed within the solar system. Several people have suggested that eruptions of a sort from the giant outer planets, from their satellites, or even from the sun may produce comets. But there is no evidence that such a process is taking place or can take place. It may be that the comet-formation process occurred late in the history of the solar system and resulted in the comets we now see, whose number is gradually being depleted by the decay process. Yet the number of known comets is increasing, possibly the result of better observing techniques. Finally, it may be that comets were a product of the formation of the solar system itself, and those we see have survived, in spite of the decay process, to the present time.

A theory has been proposed, principally by the Dutch astronomer Jan H. Oort, to account for such a comet population. According to Oort's hypothesis, the creation of the solar system resulted in a comet cloud that revolves around the sun at a distance of 50,000 to 150,000 astronomical units. Ordinarily, the comets within the cloud never approach the sun. Occasionally, however, some of them suffer a perturbing force from nearby stars, which may "jostle" them into interstellar space or into a path that will bring them into the sun on a greatly elongated orbit. As they approach the sun, additional perturbations from the large outer planets may deflect them into interstellar space or change them into periodic comets that pass regularly around the sun. After a hundred or so passages, they will be destroyed, but they will be replaced by new objects.

The supply, of course, is not inexhaustible, for the comet cloud itself is continually being depleted. However, only a few thousand or so comets at a time will be in orbits close to the sun. Oort postulates that the cloud may contain 100 billion or so objects, so that the present rate of observable comets could be sustained for some time.

The theory could also account for the family of sungrazing comets to which Comet Ikeya-Seki belongs. It is possible that the parent of the group was a much larger comet that was deflected from the cloud into the sun's vicinity. When it passed close to the sun on its first journey, the large object may have been broken up into several parts. Each of these parts would continue to move around the sun on orbits similar to, but slightly different from, that of the parent object. So each part will return on a path similar to that of the other parts. If so, we may not yet have seen the end of the sun-grazing family.

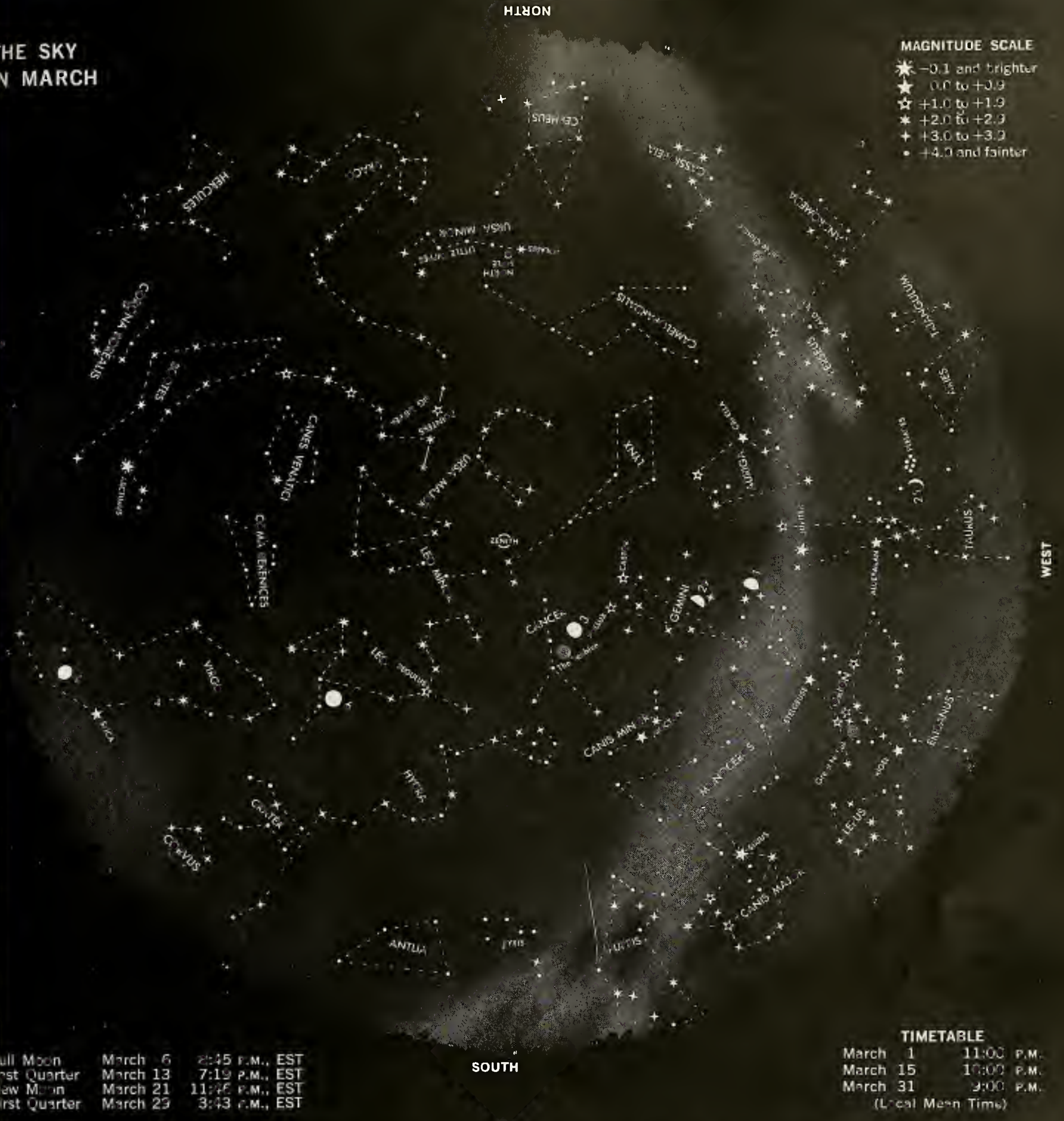
Although Comet Ikeya-Seki may not return for a thousand years or so, its brothers or cousins may continue to come in on the course blazed by an unknown, ancient parent. Each of these, in turn, may bring us another spectacular display like those of comets 1965f, 1882 II, or 1843 I.

Dr. Nicholson, the regular author of this column, is also Chairman of the American Museum-Hayden Planetarium.

[T]HE SKY [I]N MARCH

MAGNITUDE SCALE

- −0.1 and brighter
- 0.0 to +0.9
- +1.0 to +1.9
- +2.0 to +2.9
- +3.0 to +3.9
- +4.0 and fainter



[F]ull Moon	March 6	8:45 P.M., EST
[La]st Quarter	March 13	7:19 P.M., EST
[N]ew Moon	March 21	11:46 P.M., EST
[F]irst Quarter	March 29	3:43 P.M., EST

TIMETABLE

March 1	11:00 P.M.
March 15	10:00 P.M.
March 31	9:00 P.M.

(Local Mean Time)

March 1: Jupiter is in conjunction with the moon at 3:00 A.M., EST. After sundown tonight the planet will be to the right of the first quarter moon, in the southern sky. Jupiter is the brightest object in Taurus.

Venus, magnitude —4.3, reaches greatest brilliancy in the morning sky. The planet is now rising about an hour and a half before sunrise, and it appears low in the southeast as the dawn brightens.

March 4: Mercury, at greatest easterly elongation from the sun (18 degrees), is favorably placed for observation as an evening star for several days before and after this date. Look for the planet a half hour after sundown; it will then be about 10 degrees above the western horizon.

March 10: Saturn is in conjunction with the sun and moves into the morning sky.

March 11: Mercury becomes stationary in right ascension and begins to move retrograde (westward) to approach the sun rapidly.

March 17-18: Venus and the late crescent moon appear close together in the morning sky on both days. On the 17th, Venus is to the left of the moon; on the 18th, to the right.

March 20: The sun arrives at the vernal equinox, in the constellation Pisces, at 8:53 P.M., EST. Spring then begins in the Northern Hemisphere, autumn in the Southern Hemisphere. It is interesting to note that the full moon of March 6 was the harvest moon in the Southern Hemisphere.

March 21: Mercury is at inferior conjunction, passing between the sun and earth, and enters the morning sky.

March 28: Since passing Jupiter early in the morning of March 1, the moon has gone completely around the earth and will pass Jupiter again at 2:00 P.M., EST, today. Note that it was just past first quarter moon on March 1 when it was near Jupiter, but in tonight's sky it is still a crescent moon, not quite first quarter.

All Month: Only Jupiter is prominent as an evening star this month, appearing in the south as darkness begins, and setting about midnight. Mercury may also be seen as an evening star for a few days in early March, but it is never easy to see. Venus is a brilliant morning star throughout March, rising earlier in the east as the month progresses.

How a Bird Tells

Robin studies deal with "biological clocks"

By John D. Palmer

the Time of Day

THE industrious robin arises early each morning to forage through worm-laden gardens. At twilight it ceases its day's work. The following day it again rises with the sun and ventures forth to range over its territory. Day after day, month after month, this routine is seldom broken, except during migrations.

If a robin is caught and placed in a specially constructed cage, in which its movements can be automatically and continuously recorded, it is possible to quantify its activity, hour by hour, throughout the day and night, and to obtain an accurate picture of its daily agenda. During the night the robin rests quietly. With the advent of sunrise the fast is broken, and the bird engages in the busiest activity of its day. During the midday hours the amount of activity gradually lessens, until, in the cool of the early evening and before the encroachment of dark, a second surge of activity occurs.

This pattern is neither new nor surprising; bird watchers have long known that for the utmost enjoyment of their avocation they must venture forth at dawn. Also, the early morning maximum is what one might predict on theoretical grounds alone, for metabolic processes in birds run at a rate considerably higher than that of man, when the two are compared on an ounce-for-ounce basis. Therefore, birds require relatively large amounts of food for fuel. It is only natural, then, that after living through the night on stored food, the robin begins its day with an active search for nourishment to replenish its depleted reserves. If the caged bird's movements are recorded continuously for weeks at a time, it is found that this activity pattern is repeated virtually unchanged day after day. Because of the recurrent activity pulses, such cyclic behavior is referred to as the bird's activity "rhythm." This kind of rhythm and other biological rhythms have been described for several birds, a great many other animals, and numerous plants. In fact, because biological rhyt' are so universally distributed th ʼiout the kingdom of living thing -hould probably be recognized as a fundamental property of life itself.

The top graph on page 50 suggests that the onset of daylight is the bird's alarm clock, signaling the time to awake. The bird is active only during the daylight hours, and sunset appears to dictate the time it retires. During long-term studies, the bird's proclivity for day activity is repeated with such constancy that chance coincidence is unlikely. However, even obvious relationships should be subjected to objective experimentation. To test the role of sunrise, daylight, and sunset in the genesis of the rhythm, one could relocate a bird geographically—for example, transport it from New York to California, where sunrise occurs three hours later. Then the bird could be observed in its new location to see if it awoke three hours later than usual —at the time of California sunrise. An even more extreme test would be to translocate the bird rapidly to the opposite side of the earth, and thus completely reverse the day–night schedule to which it was accustomed (noon in New York corresponds to midnight in Chungking, China). However, jet airline fares are sufficiently high, even for a robin, to make more economical steps practical. The same effects can be observed if a laboratory is equipped to subject the bird to darkness during the daytime and light throughout the night. We subjected several birds to such a change in the laboratory, and found that their rhythms could be completely reversed in an interval as short as three days in the reversed light regime. The birds now awoke at the time they had previously retired and went to roost at the time they previously awoke.

THIS and other related studies would lead one to believe that the changes between light and darkness and the presence of light itself were the causes of activity rhythm. Yet this is not the case. As further experiments showed, the rhythms per se are essentially independent of such changes.

The curve in the top graph on page 50 was obtained from a robin whose cage had been placed adjacent to a window in the laboratory, thereby exposing the bird to the light changes natural in its wild habitat. (It might be noted here that all robins tested showed curves of virtually the same shape.) The caged bird's pattern of activity corresponded to the hours of daylight. However, if the cage was removed from the window and placed in a special chamber in the laboratory, in which the birds were isolated under a dim light source of constant intensity for day after day (the temperature was also constant), a remarkable observation was made. Periods of activity alternated with those of quiescence in an almost identical manner to those in natural daylight. The bottom graph on page 50 shows the activity pattern on the first day after the bird was placed in static conditions of light and temperature. The robin awoke at the same time as when it was kept in alternating day–night conditions, was most active during early and mid-morning, slacked off through midday, and terminated the cycle with an evening burst of activity before retiring. In some way the bird was able to mimic the behavior of its former neighbors in nature, even when completely isolated from them in artificial and unvarying laboratory conditions.

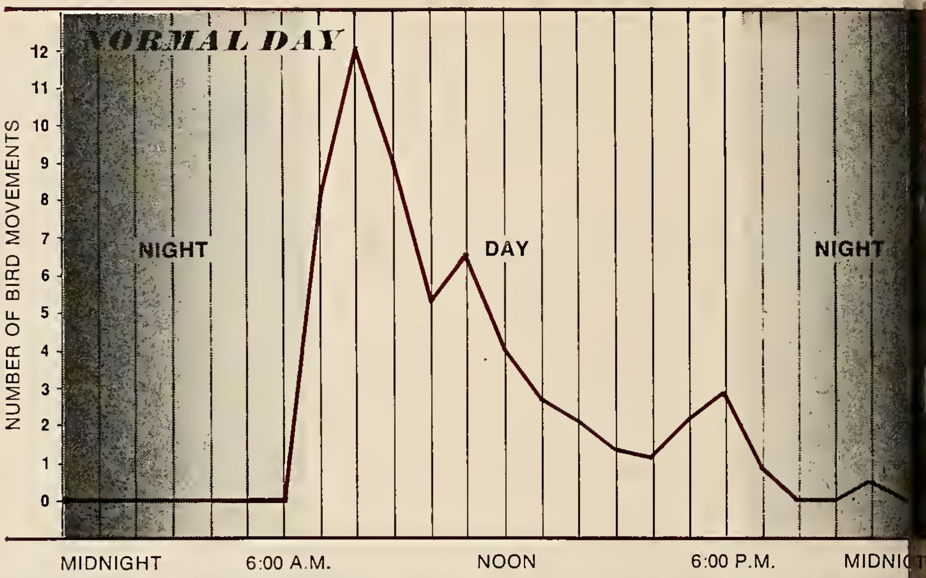
This ability of birds (and most other organisms) to "tell time" even when they are maintained in constant conditions, has puzzled biologists since the first experiment was made in 1729. Most investigators now attribute the ability to some as-yet-unknown physiological mechanism that resides within the organism and is geared to body functions in such a way that it adjusts the rates of these processes to produce overt biological rhythms. This enigmatic mechanism is popularly called the "biological clock."

An interesting feature of biological rhythms is that the period (the interval between the onset of two consecutive times of activity) usually changes slightly when the organism is placed in constant conditions in the laboratory. The period no longer has a duration of 24 hours as it did in nature, but now becomes a little longer or shorter, depending on the species of animal

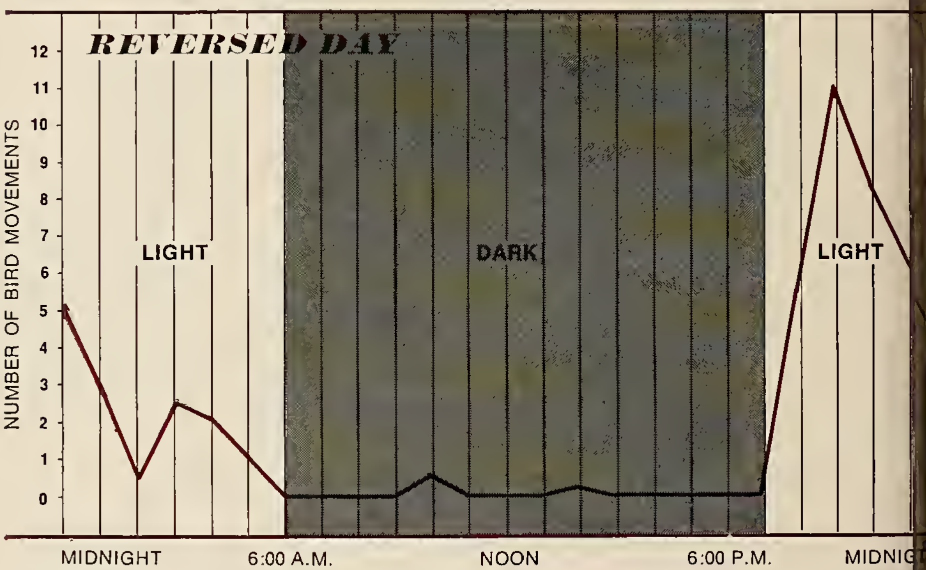
studied. Such a change is seen in the graphs on these pages, which portray the rhythm of a robin during the first five days after it was placed in constant light–temperature conditions. Notice that each day the activity phase of the rhythm starts and ends a little later than that of the preceding day, so that after several days the activity is no longer centered between the times of sunrise and sunset in nature, but has shifted by a few hours. The active phase continues to drift slightly later each day for the duration of the time the bird is kept in static conditions. If several of the periods are averaged, one finds that the period of the rhythm has become a little over 25 hours long. This slight lengthening (or shortening, depending on the species and individual) is a property of most biological rhythms that persists in constant conditions. Because the period of the rhythm is altered slightly from 24 hours, these rhythms are referred to as "circadian" (*circa* = about; *diem* = day)—rhythms about a day long.

It now becomes clear that the bird's clock must be running constantly, but that when the bird is free in its natural habitat, the rhythm is entrained by the day–night cycles to a period of 24 hours. In addition, the phase of the rhythm (the position in the cycle at which the most activity occurs) is similarly determined: the bird is exclusively day active.

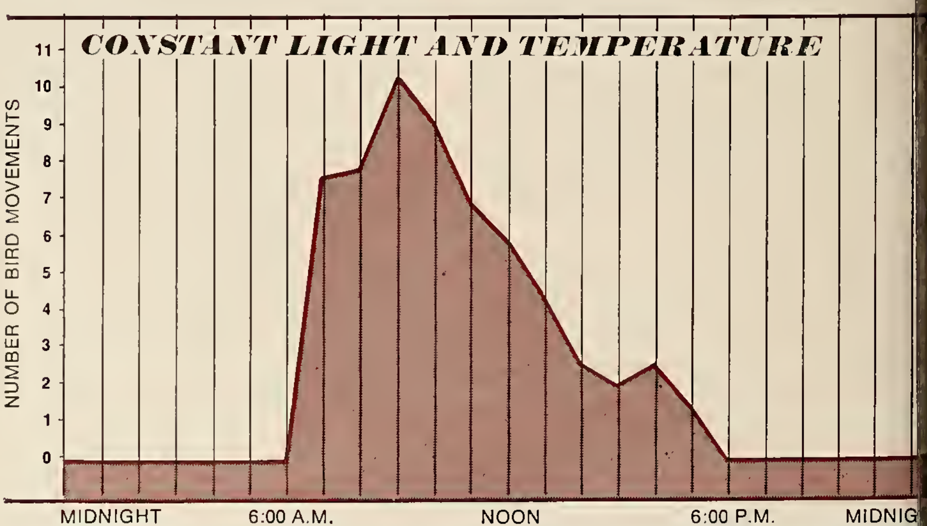
So restricted to light are day-active birds that even parts of their anatomy reflect the tendency—the eye, for instance, shows several modifications. The actual light-perceptive units of vision in the eye are the retinal rods and cones: the cones are responsible for color vision and, in general, only respond to relatively bright light intensities; the rods do not distinguish color, but are highly sensitive to weak light intensities. As would be expected, the retinas of such diurnal birds as the robin are rich in cones, while the visual receptor cells in nocturnal birds, such as the owl, are almost exclusively rods. Another feature unique to the eye of day-active birds is a scattering of red, yellow, and orange oil droplets throughout the retina. These heighten the contrast of colored objects in the field of view. Birds that rise the earliest—and the worm-catching robin is, of course, among them—have the greatest number of red droplets. Night-active birds have, primarily,



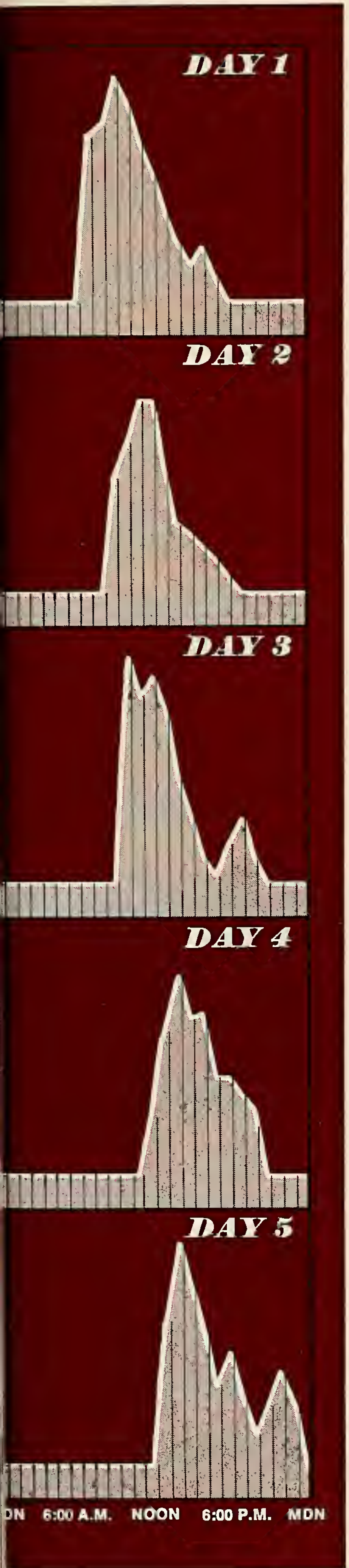
Exposed to normal light changes, robin has a burst of activity in the morning that moderates gradually until another slight burst occurs just before dark.



Activity curve of same robin, on the fourth day of a reversed light cycle, shows that bird has co-ordinated its movements to simulated daylight hours.



On its first day's exposure to constant light and temperature, bird's activity rhythm is essentially unaltered. On succeeding days, as shown in graphs at right, the rhythm period gradually increases to slightly over 25 hours.



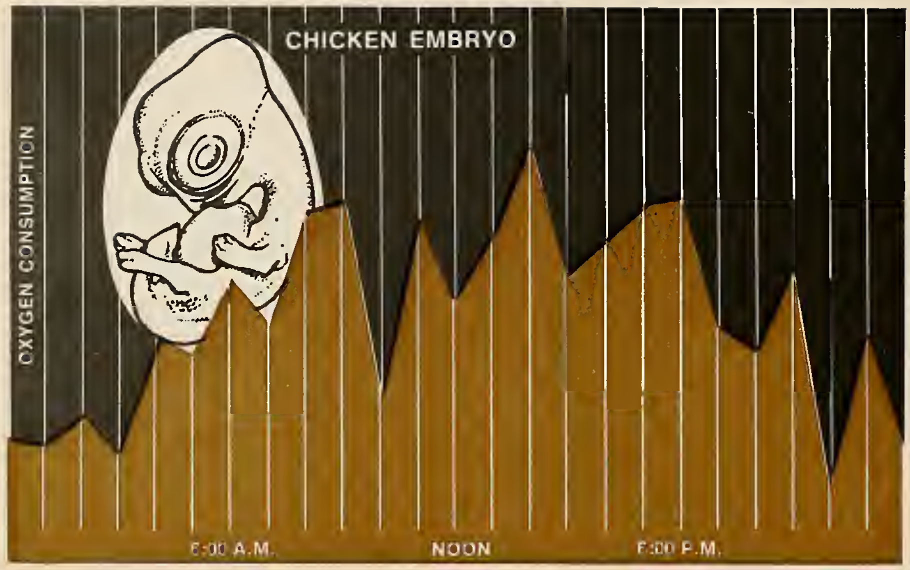
pale or colorless droplets. Their eyes are usually larger than those of diurnal species; in some owls, for example, they may even equal or exceed the weight of the brain, and are of such enormous size that they nearly touch each other in the median plane of the skull. (In some owls, the eyeballs are as large as a man's.)

The clock is a fundamental "structure" of the adult bird and important in its daily life. To discover the time during the development of the young bird at which the clock appears, two German investigators, Drs. Jurgen Aschoff and Johannes Meyer-Lohmann, placed chickens in cages as soon as they hatched and recorded their activity under constant conditions. As would be expected, when the chicks first emerged from their protective shells, their activity was feeble and intermittent, but it increased concomitantly with their age. By the third day, a distinct activity rhythm was obvious, and as they developed further in strength and vigor, the amplitude of the rhythm increased correspondingly. By the seventh day, when observations were discontinued, a large-amplitude rhythm, with a periodicity slightly longer than 25 hours, was present.

Because the embryonic development of birds is extrauterine (takes place outside the maternal parent, in the egg), it is easy to follow the development of the chick from the single-celled stage to the time it hatches. The initially tiny embryo within the egg is a living, metabolizing system, and therefore requires oxygen. This diffuses into the egg through the shell and is consumed by the growing embryo. Drs. Franklin Barnwell and Leland Johnson of Northwestern University, also experimenting with chickens, measured the rate at which oxygen moves through the shell and is consumed, and found that by the seventh day—when the embryo is only 3/4 inch long, and approximately 14 days before it hatches—a distinct rhythm in the rate of oxygen consumption is already present (*see diagram, page 52*). This rhythm exists in spite of the eggs having been kept in constant conditions from the onset of the embryo's development. Not once were they exposed to a normal day–night cycle.

Activity and oxygen consumption are only two of many rhythmic processes in birds. A few other common rhythms will be mentioned. For example, closely associated with activity rhythms, and especially associated with the times of peak activity, are effusions in song. The robin begins to sing as soon as it awakens. Like most other birds that are active by day, it gradually moderates its singing to a low ebb in the early afternoon. Toward evening, singing is again resumed, and one last encore emanates before the sun sets. Hand in hand with the song cycle, but corresponding directly with greater activity during the day, is a rhythm in body temperature, mimicking the form of the activity rhythm. The robin, for example, has an average temperature that slightly exceeds 106°F., and that varies rhythmically during the day through a range of about 6°. The avian heartbeat is very rapid (in the robin it averages about 570 beats per minute and ranges between 520 and 620) and, like other rhythmic processes, undergoes a regular daily cycle in the rapidity of its pulsations. It is interesting to note in passing that the blood pressure (which in the robin is 118/80—about the same as in an adult man) does not change appreciably with alterations in the rate of heartbeat. The chicken has more red blood cells at midnight than at noon, and the ratio of various kinds of white blood cells fluctuates in a regular pattern each day. During the reproductive season most passerine birds and many ducks and woodpeckers lay their eggs at 24-hour intervals until the clutch is completed. There are other rhythms that could also be mentioned. However, let us conclude by discussing one of the most interesting functions of the avian clock—its affiliation with celestial navigation.

THROUGH banding and recapturing, it has been found that birds possess remarkable powers of navigation, some being able to migrate hundreds or thousands of miles to an exact geographical locality. To cite an example, careful studies have shown that each spring 75 per cent of the robins in the United States return to within a five-mile radius of their northern home of the previous year (about the same precision as our Intercontinental Ballistic Missiles). This also includes the one-year-olds, who have never made the journey before. To obtain such homing accuracy, an animal must possess the complex know-how of bicoordinate navigation. Birds obviously have the faculty, but this facet of their behavior is only vaguely understood at present.

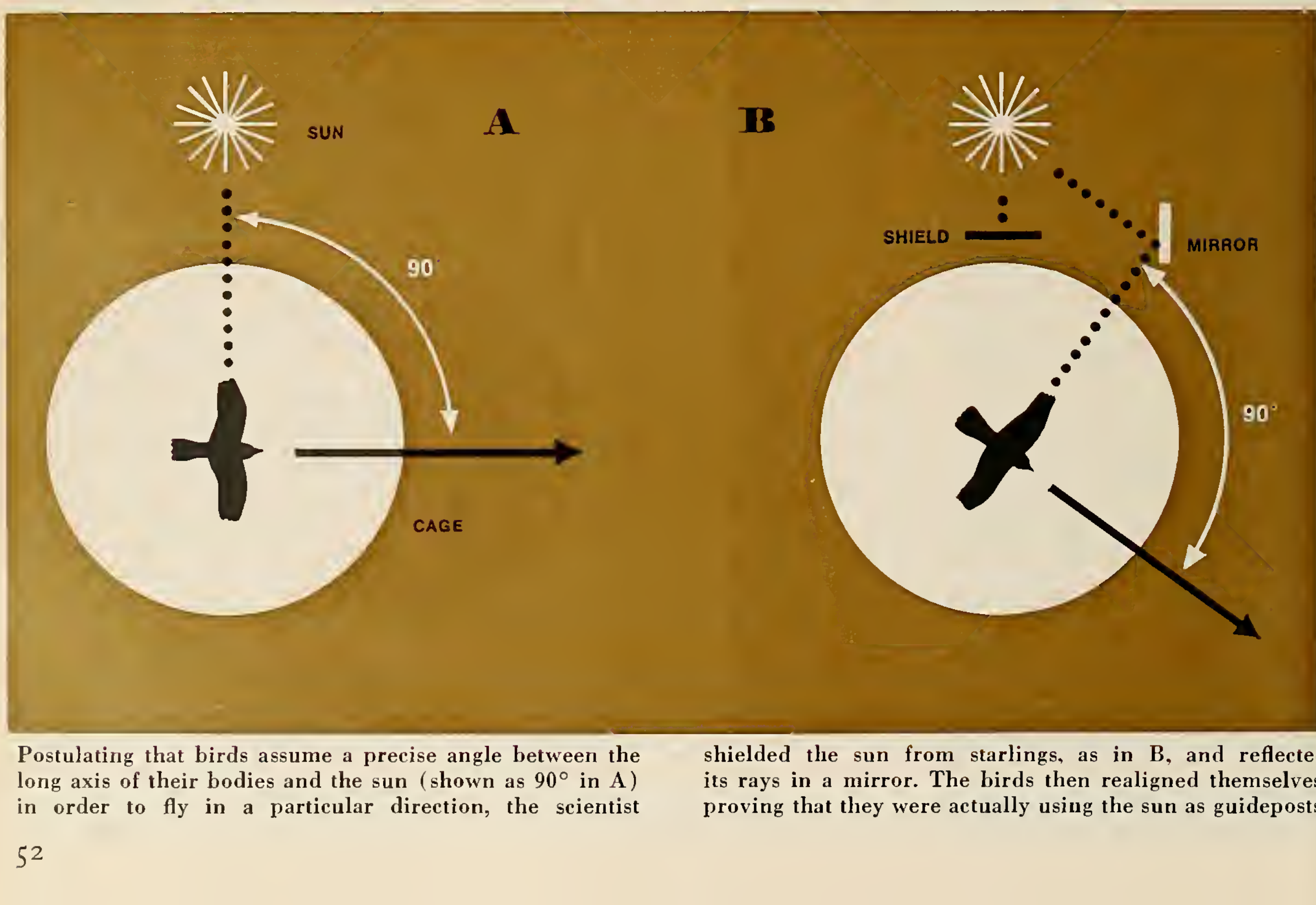


Although seven-day-old embryos have not been exposed to 24-hour day–night cycle, their oxygen consumption rate is higher in daytime than nighttime.

However, in recent years some insight has been gained into their ability to fly in a particular compass direction, and this, of course, is a first approximation to the more intricate facets of bicoordinate navigation.

Dr. Gustave Kramer, the late German ornithologist, observed that several starlings maintained in an outside aviary became unusually restless with the onset of the migratory season: they continually fluttered on their perches (a sort of flying in place) and oriented themselves to face in the direction of their normal migratory route. On overcast days the restlessness continued, but now the birds became disoriented and no longer faced only a preferred direction. Dr. Kramer surmised that they must be using the sun to orient themselves, and he devised an ingeniously simple experiment to test the hypothesis. After establishing the direction of fluttering, he would blot out the birds' direct view of the sun and, with the use of a mirror, reflect the image of the sun into the cage from various other directions. The birds would quickly realign their body axis according to the new, apparent position of the sun as reflected from the mirror, and flutter in that direction. Surely they were using the position of the sun as a guidepost to direct their abortive migratory attempts.

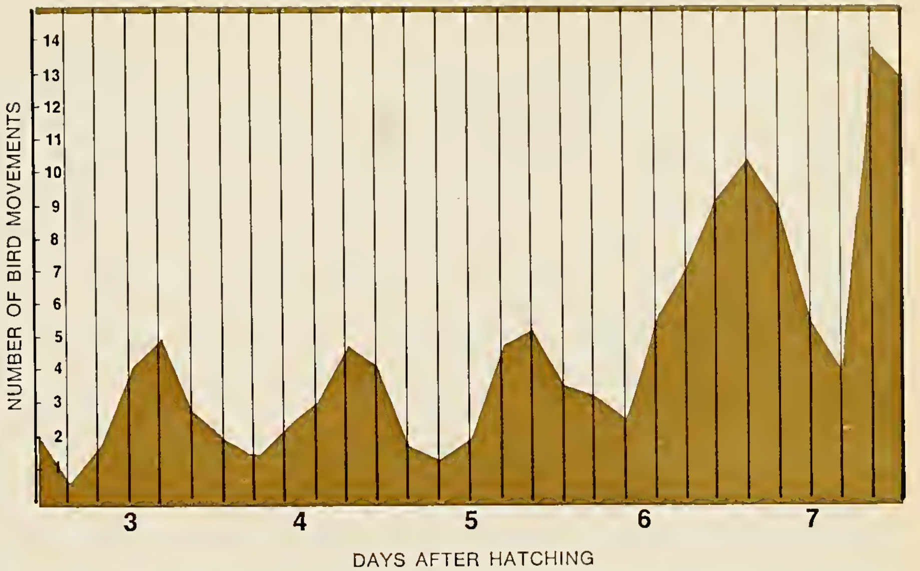
When caged outside in daylight, a starling would consistently flutter in a particular direction (north in the spring, south in the fall) and, like the needle of a compass, "point" in this preferred direction all through the day. Meanwhile, the sun, of course, moved across the sky from east to west, thus providing a rather elusive point of reference. This can only mean that the bird, in order to maintain a constant direction of orientation, had continually to make allowance for the sun's changing positions. That is, in order to sustain a northward orientation it was necessary for the bird to keep the sun over its right shoulder in the morning, directly behind at noon, and to its left side during the afternoon hours. Because this difficult task was done unerringly, it must be as-



Postulating that birds assume a precise angle between the long axis of their bodies and the sun (shown as 90° in A) in order to fly in a particular direction, the scientist shielded the sun from starlings, as in B, and reflected its rays in a mirror. The birds then realigned themselves, proving that they were actually using the sun as guideposts.

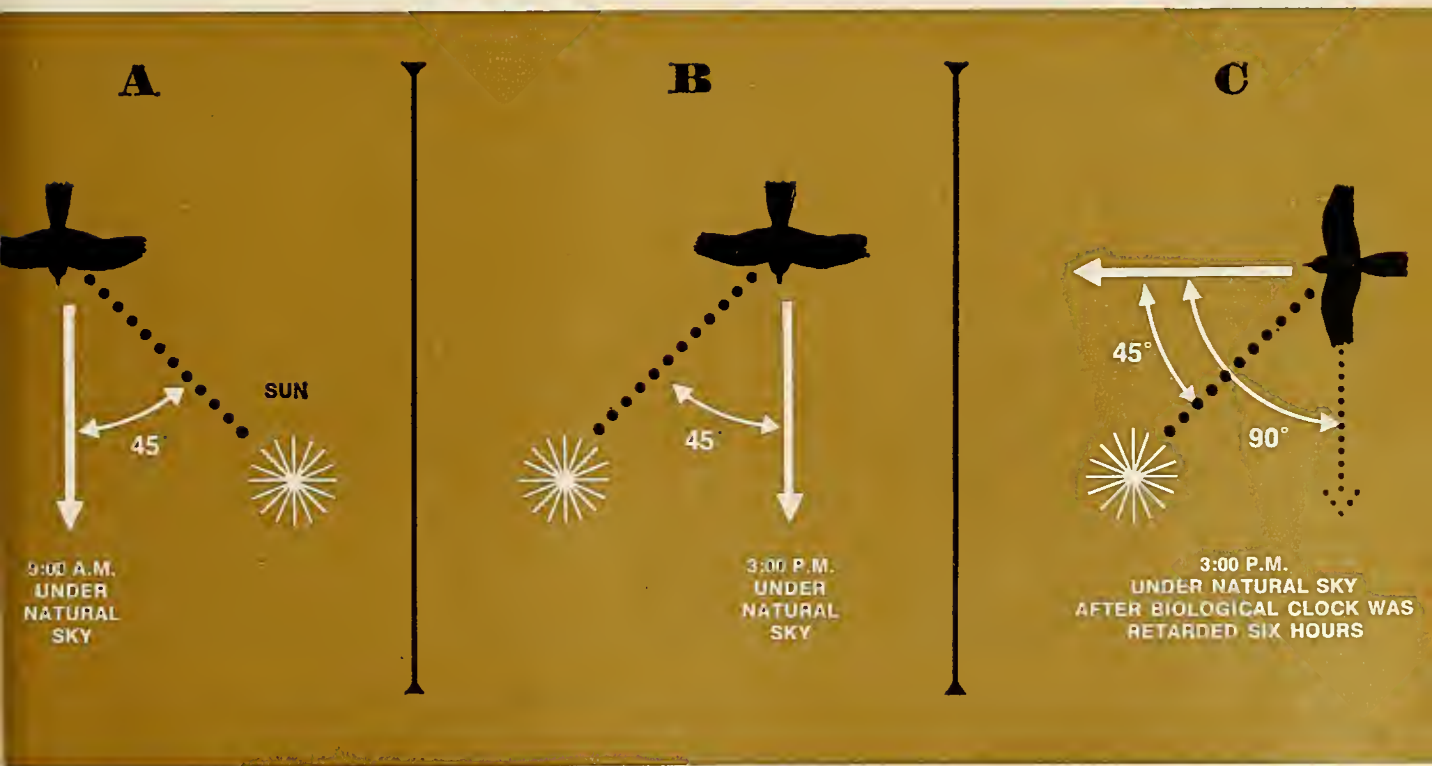
sumed that the bird always had a rather exact notion of the time of day, permitting it to maintain the proper angle of orientation in relation to changing sun positions.

To demonstrate the time-compensated nature of sun orientation, Dr. Klaus Hoffman, a former colleague of Kramer, performed the following experiment. After establishing the directional orientation of a bird under the natural sky, he subjected it to artificial days in the laboratory in which "day" began and ended six hours later than in the outdoor cycle. After several days of this treatment he again tested the bird's orientation in the natural daylight and found that now the direction of fluttering was shifted by about 90° clockwise from its former course (*diagram below*). Conversely, birds restricted to artificial days that started and ended six hours *before* the normal day now chose a direction 90° *counterclockwise* to the pretreatment preference. Clearly, the bird's biological clocks had been reset by a quarter of a day, and these changes were now reflected in the corresponding changes in the bird's orientation to the sun. Again, as with so many other avian processes, the fundamental importance of the clock became manifest.

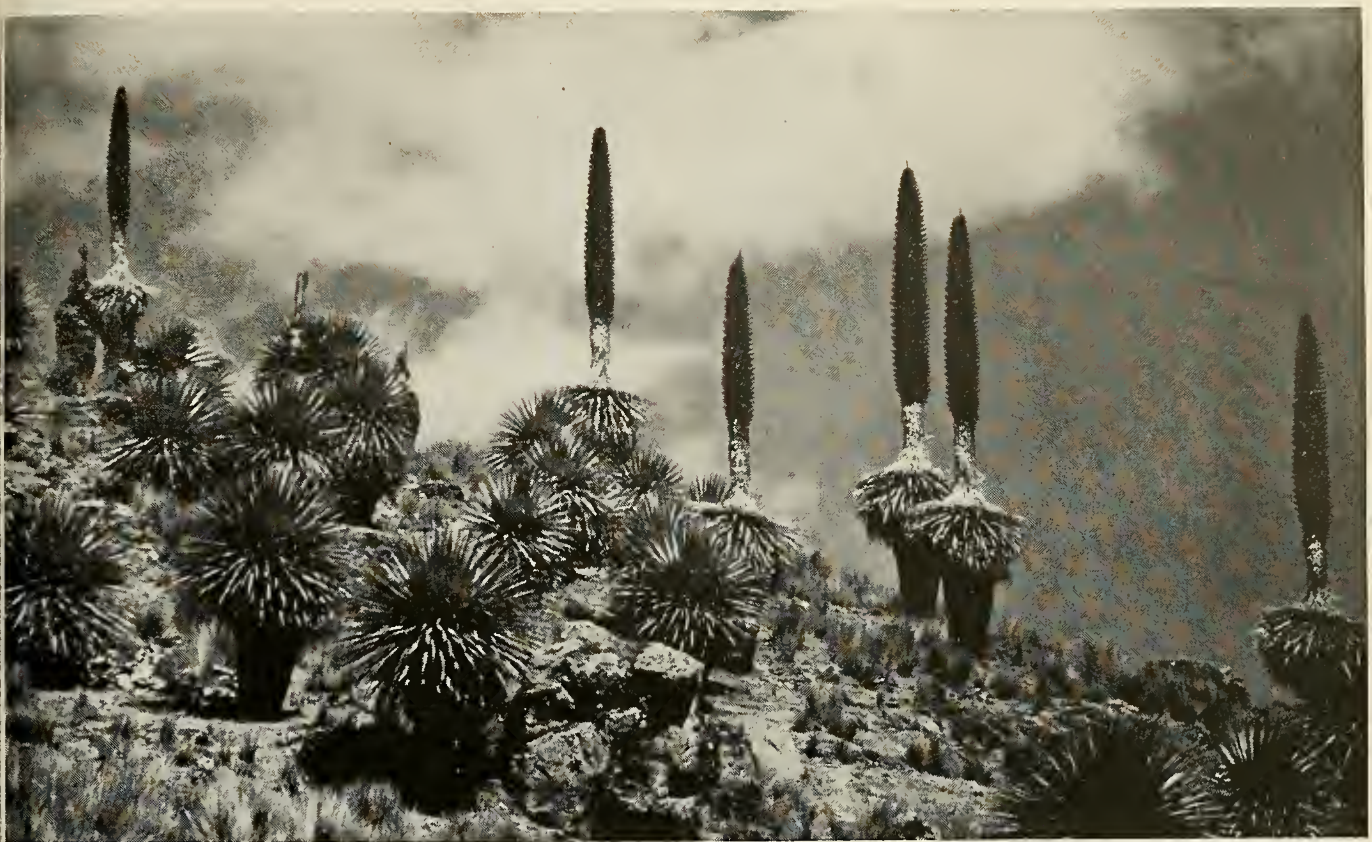


Activity rhythm of new chicks, even though held under constant light and temperature, becomes distinct by the third day, more persistent thereafter.

Without question, the function of the biological clock is paramount in the normal, everyday life of birds: it controls a whole host of fundamental physiological processes and is a requisite for spatial orientation. Since many life processes in other animals, including man, are also contingent upon their biological clocks, it is vitally important to biologists to discover where in the organism the clock dwells and how it functions. Sparsely scattered reports have appeared over the years purporting to have finally discovered the clock (the reported "clocks" are usually particular segments of nervous or hormonal systems), but further investigations have always disproved the claims. The overt rhythmicity of so many biological processes establishes its presence. but after well over two hundred years of inquiry, its place of residence and its driving force remain elusive.



To fly due south, a bird would have to maintain an angle of about 45° to the left of the sun at 9:00 A.M. (A), and 45° to the sun's right at 3:00 P.M. (B). To show that its biological clock determined its orientation, light cycle was delayed six hours and the bird tested at 3:00 P.M. Starling now took up 9:00 A.M. angle (compare C and A).



COLONY of *Puya raimondii*, near Mina Huinac, is in the Cordillera Negra, Peru, and contains old and new plants.

BLOOMED-OUT stalks of *Puya raimondii* stand out against the sky, *above*. Younger plants cover lower part of slope.

Giants of the Puna

Bromeliad of the Peruvian highlands lends itself to many uses

By FRED D. AYRES

ANTONIO RAIMONDI arrived in Lima, Peru, from Italy in 1850, about two months before his twenty-fourth birthday. He soon began a long career of teaching, exploration, and writing. For more than twenty years he traveled extensively in Peru, penetrating remote areas and collecting data on the climate, flora, fauna, geology, and mineral resources of various regions. The results of these and other investigations are in a series of works published between 1854 and 1886. He died in 1890 in San Pedro de Lloc, near Pacasmayo. In present-day Peru there are streets, schools, and a glacier named for him.

In the highlands Raimondi observed a plant some 30 feet tall—growing at elevations of about 13,000 feet—which he named *Pourretia gigantea;* but this did not accord with the international rules of botanical nomenclature, and later the botanist H. Harms substituted the name *Puya raimondii.* This plant is the largest of all bromeliads (plants that produce aerial root systems) and, compared with other flora found in its rocky habitat, it is a veritable giant.

Few travelers in South America have seen *Puya raimondii*, and even fewer have seen it in bloom. It is moderately common in Peru and Bolivia, but the altitude at which it grows makes it inconvenient to reach. Near Mina Huinac, in Peru, about ten miles south of the high point of the Huarás-Casma road, the plants are scattered over half a square mile on the slopes of an open canyon. A rough count indicated that there were at least 8,000 individuals of all sizes in the group.

The trunk of *Puya raimondii* bears at its top a dense rosette of leaves, which may reach six feet or more in diameter, depending on the age of the plant. The leaves, which are three or four feet long, are four inches wide at the base. The leaf edges are armed with brown-colored barbs, three-eighths of an inch long, spaced at intervals of two inches. They are needle-sharp and directed inward, an arrangement that can be a wicked trap for the unwary.

It has been estimated that *Puya raimondii* requires over a hundred years to reach a height of ten feet. Eventually, at about this height, the plant sends up from the rosette of leaves a columnar bloom stalk, which reaches its maximum height of fifteen to

twenty feet after about three months. This gives the plant an over-all height of approximately thirty feet.

A stalk reaches maturity at the age of five or six years. When it nears its full height, densely packed branches, or spikelets, eight inches long and shaped like an unhusked ear of corn, grow outward from it. It is from these branches that the practically odorless, greenish-white flowers blossom, a total of twenty or thirty on each branch. At any one time, only about a third of this total is in evidence, for flowering progresses outward from the base of the branch, and older flowers wither as newer ones form. The cigar-shaped column presents a pattern of these flowered "ears" evenly arranged in multiple spirals that wind around the stalk. Hummingbirds are often seen hovering about the blooms. The seed capsules are arranged in compact egg-shaped groups of three, and on an average the ones I examined had 23 of these groups per branch. The average number of seeds in a single capsule was 150 (*see photograph below*); the number of branches on one stalk about 600 or 700. By taking 650 as a representative number and multiplying, one obtains six or seven million as a reasonable estimate of the number of seeds produced by a single plant. The chance of any one of these seeds producing another mature plant must be less than one in a million.

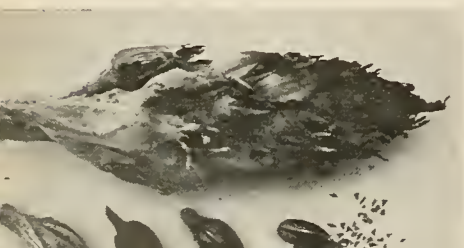
Once *Puya raimondii* has bloomed and produced its prodigious crop of seeds, it dies. In this particular colony, however, whether or not it dies naturally is of little importance. The residents of the region cut down the plants that have bloomed in order to utilize the "trunks," or stalks. Sheepherders use the stalks for rafters in small huts as well as for fuel. Residents of the area also make them into

STALK of *Puya raimondii* is at height of its bloom; it flowers once and dies.

roof beams and racks for a variety of things, including band instruments and meat. Inventive persons in the town of Vischongo have hollowed out sections of the stalk and made drum bodies and wastepaper baskets from them. Sawed in sections, they make light, serviceable stools, and have been used for seats and benches in schools. Emma Cerrate, of the Natural History Museum of Lima, reported that in the region north of Chiquián some of the isolated small schools were without seats for the pupils. This was remedied by each student carrying his own *Puya* stool with him to school in the morning, and returning with it to his home in the afternoon.

As the plant grows, the great ball of fresh leaves at the top is elevated more and more above ground level. The older, lower leaves wither and dry, and are left draped around the trunk. On most of the *Puya* in a colony, the portion of the trunk below the leaf rosette is charcoal black, and for a good reason—the surface layer *is* charcoal. Sometimes the local inhabitants burn these tinder-dry masses for amusement. It is possible that some have been ignited accidentally from fires in the puna grass, which occasionally were set in the belief that the succeeding growth would provide better grazing. Most of the larger *Puya* seem to survive a fire with no serious damage. The basal ends of the flat leaves are packed around the trunk almost as tightly as cards in an unopened deck, and by the time the fire dies out, it is still four or five inches from the trunk proper; the remaining sheath of leaf stumps provides good protection. The lower green leaves of the rosette protect the crown of the plant during the ten minutes or so that the fire burns.

Puya raimondii is probably losing a battle for survival. The small, young plants—extremely few in number, at best—are subject to appreciable hazards, at times from grass fires, but more often from grazing sheep. Also, their slow rate of growth makes them vulnerable for an extended time. It is to be hoped that selected groups can be given adequate protection. The giants of the *puna* are remarkable enough, and are scarce enough, to deserve it.



FLORET, lower left, grows on spikelet, top, and produces three seed capsules.

FLOWER of mature plant, *right*, is of greenish-white color and has little odor.

FIRE, often set deliberately, does not injure the upper portion of the plant.

Grazing Mollusks In The Weeds

Sea hare lore was first recorded by Pliny

By David Linton

A shell collector, wading in the shallows of a tropical shore, is some-:imes startled to see a purplish cloud ;preading round his feet. The chances ıre that he has stumbled upon the ıarmless but unusual mollusk *Aplysia*, he sea hare. This animal's curious 'ink" is of questionable defense ralue, however, because the sea hare ;annot dart away under cover of the :loud, as an octopus can. Therefore, he ink may actually call attention to ın animal that would otherwise escape ıotice. Once the sea hare is discov-:red, it is easy to see how it got its ıame: when sitting still it has the ounded, bunched-up profile of a siting rabbit, and two earlike tentacles tick up from the top of its head.

In the past two thousand years the ea hare has been variously described ıs a fish, worm, holothurian, cuttleish, or snail. While it may show some uperficial resemblance to each of hese groups, the snail is the only one o which it is closely related. It beongs to the order Opisthobranchia, vhich includes the sea slugs—marine nails that do not have shells. Both sea lugs and sea hares have shells in the arval stage, but while the adult slug oses its shell completely, the sea hare hell remains vestigial, concealed inide the mantle. Like all opisthoıranchs, sea hares are hermaphroditc; each individual has both male and emale reproductive organs and can ılay either role in fertilization.

Thirty-five species of this animal ıre now recognized, and two-thirds of hem are found in tropical and subropical waters. Early investigators, not knowing that three of the species are circumtropical in distribution, gave different scientific names to members of the same species that were found in different regions. Only one species has been found north of the Arctic Circle and none in the Antarctic. Some are less than two inches long, while one reaches a length of two feet. Seven species are found on the east coast of North America, the largest ones in the warm waters of the West Indies and the coast of Florida, and two species have been recorded at Fishers Island (off Connecticut) and Rhode Island. The West Coast harbors some of the larger *Aplysia*, such as *A. californica* Cooper, which attains a length of fifteen inches.

:oloration of sea hares is affected by he color of weeds on which they feed. 'he green individuals at the left were hotographed off the coast of Florida.

The best-known of the sea hares is *Aplysia dactylomela* Rang, distributed around the world in the tropics. Individuals average about a foot in length, and range in color from yellow through green to brown. All are marked with brown or black rings or spots, usually with a network of fine lines between them, and along the animal's back are two frilled, or fluted, "fans" that wave in the currents of the water and undulate gracefully as the animal grazes on seaweed. The fans, or parapodia, extend upward from the animal's sides.

The underside of this animal consists of a single foot, rather like that of a snail, running the entire length of the body. The head and neck are flexible and can be extended to about half the length of the body. There are two pairs of tentacles: the anterior pair extend from the front corners of the head and function as tactile organs. The posterior pair, or rhinophores, look like rabbit ears and serve an olfactory function. The small eyes are located at the base of the rhinophores. Seen from its own level, a sea hare grazing through shoulder-high turtle grass resembles nothing so much as a fat cow in a meadow. Like a cow, it raises its head from time to time to look around, and then moves on with ponderous deliberation.

Aplysia feed entirely on seaweed, and are thus confined to the littoral and sublittoral zones where seaweed grows. Young *Aplysia* live among the red weeds farthest from the shore. As they mature, they move into the laminarian, or brown weed, zone. Once or twice a year they migrate to the intertidal zone to mate and lay eggs. No one knows how long they live.

The coloration of *Aplysia* changes—apparently through a mechanism that extracts the color from the weeds on which the animal feeds. (They are not, however, capable of changing color rapidly, as do chameleons or octopuses.) Thus a young adult may be reddish, like the red weeds it eats. As it moves shoreward, it may become brown and then green. One experiment has shown that West Coast sea hares of various colors change to a uniform light tan when fed parsley leaves and celery tops for one to three months. This changeable base color is overlaid by permanent black or brown pigment that forms the rings or spots and the dark connecting lines.

When eating, the sea hare grasps a piece of seaweed in its mouth and scrapes off a particle with a long, ribbon-like tongue, the radula, which is covered with rows of backward-slanting "teeth." The food is stored in a gizzard-like crop and masticated before digestion.

Although *Aplysia* can swim, they usually crawl in a slow, snail-like gait. The front part of the foot is raised and extended forward as much as half the length of the animal. Then a wave of muscular contraction sweeps along the foot, drawing the animal forward. Normally, one wave succeeds another every six to eight seconds.

In the typical gastropod the viscera are enclosed in a mantle, which is in turn enclosed by a shell. The genital glands, digestive tract, and kidney all discharge into the pallial cavity, a space between the body and the mantle. In the adult sea hare, however, the shell is merely a thin, horny

plate, with the mantle grown over it.

The ctenidium—the animal's respiratory organ, or gill—is attached to the floor of the pallial cavity, and just in front of it is a sensory organ, the osphradium, which regulates the position of the ctenidium and "tests" the water for the amount of oxygen it contains. The purple gland and the opaline gland, which is the source of an irritating secretion in some species, also open into the pallial cavity.

A common genital aperture is located on the right side of the floor of the pallial cavity just under the forward edge of the overhanging mantle. Inside, the duct is divided into two sections—a large hermaphrodite duct (containing a vaginal duct and an oviduct) and a small spermatic duct. The animal's penis is located on its head at the base of the right anterior tentacle. In copulating, the animal acting as a male inserts its head between the parapodia of the animal acting as a female, and the penis enters the common genital aperture. At the same time, the "male" animal can be acting as a female to another individual. As many as fifteen sea hares have been observed coupling thus in a chain: in a few instances, the two ends of the chain were joined to form a ring, in which each animal was acting both as male and female.

After fertilization the eggs move along a passage lined with mucous glands, where they are encapsulated with a gelatinous substance and strung together into a long yellow or orange filament. This filament then passes out through the oviduct and the common genital opening. Sometimes it will follow the ciliated spermatic groove, which runs from the opening to the penis, and appears to be issuing from the head of the sea hare, but usually the egg thread will break free a short distance from the genital opening.

As the sea hare moves slowly along the ocean floor, the thread of eggs is extruded in spurts and becomes entangled in the weeds and rocks. It may be as long as fifty feet and contain more than 650,000 eggs. Many of the eggs are eaten by such predators as starfish. After eleven or twelve days those that survive become free-swimming larvae, with an operculum and a coiled shell like a snail. Many are consumed by hydroids, flatworms, crabs, small fish, or sea anemones as they move out into deeper water. Here they undergo metamorphosis to the adult form and begin feeding on the red weeds. As they mature, they migrate shoreward, gradually changing color, until impelled to the intertidal zone where they couple and spawn.

Sea hares have been looked upon with awe and surrounded by superstition from earliest times, perhaps because the secretions of some species are foul smelling or irritating to the skin. Witches were thought to use se[a] hares in their brews, and as recent[ly] as 1911 an encyclopedia stated th[at] the secretion of one of the animal['s] glands "is said to be poisonous."

THE oldest version of this folk ta[le] was recorded by Pliny in the fir[st] century A.D.: "Wonderful things a[re] related of the sea-hare (Lepus Mar[i]nus). To some it is poison if given i[n]

MOLLUSK's shell is a mere horny plate hidden under the mantle between back "fans." Two sets of antennae serve [as] its tactile and olfactory organs, *righ[t]*

SEA HARES graze on seaweed, as above, storing it in their crop for mastication. EGGS are laid in long threads, *righ[t]* and become larvae in about twelve day[s]

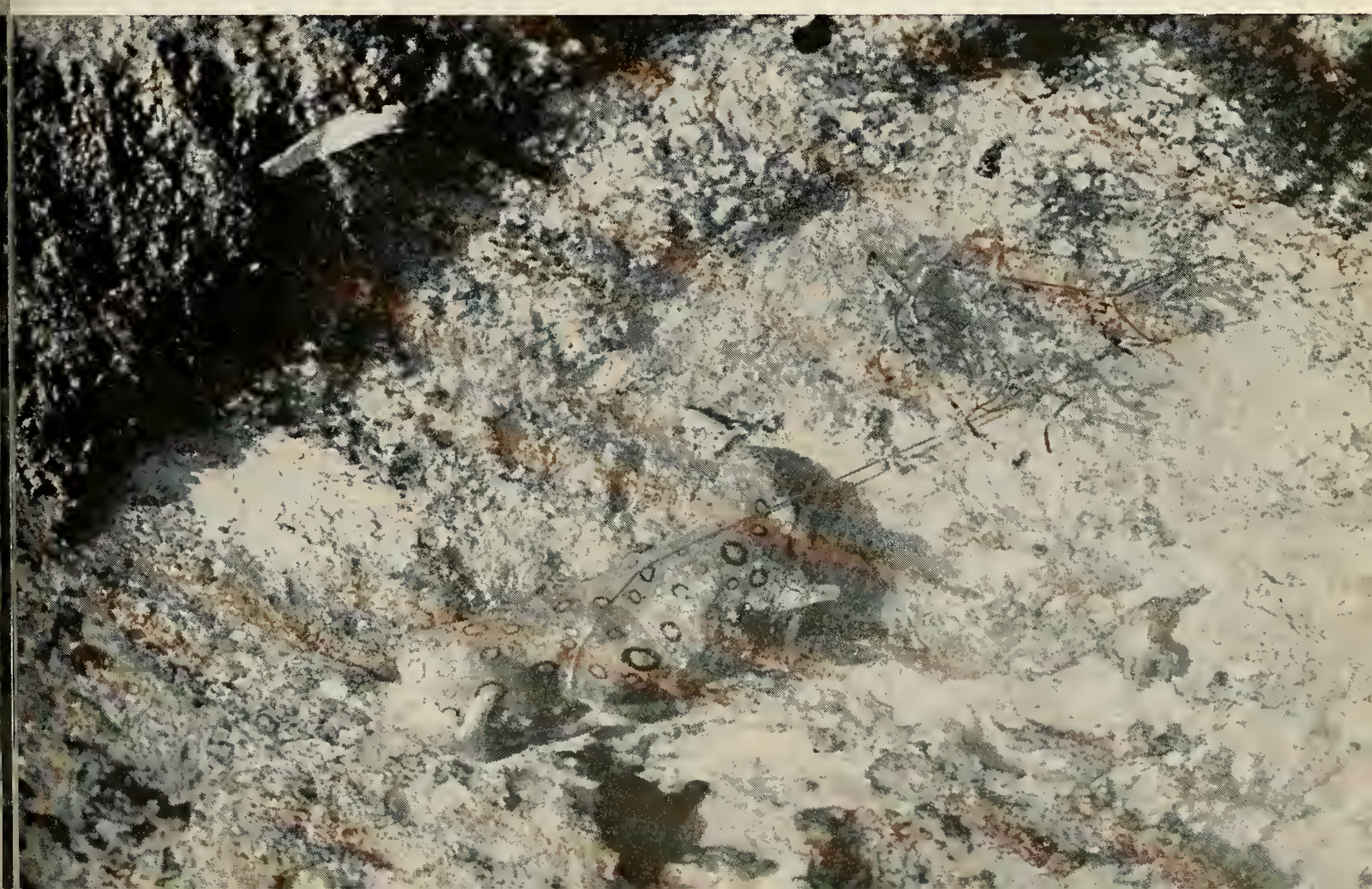
drink or food, to others if merely seen, since pregnant women, if they have but looked at one (the female, that is, of the species), at once feel nausea, show by regurgitation signs of a disordered stomach, and then miscarry. The remedy is a male specimen, specially hardened for this purpose with salt, to be worn in a bracelet. In the sea, however, it does not hurt, even by touch. . . . Struck by it a human being smells of fish; this is the first symptom by which such poisoning is detected. Furthermore, the victims die in the same number of days as the hare has lived. . . . They say that in India the sea-hare is never caught alive; and that inversely man is there poisonous to the hare; that even a mere touch of a human finger in the sea is fatal to it."

Three of the antidotes Pliny mentions to counteract the "poison" of the sea hare are "the flesh of river frogs . . . or the broth drunk after boiling them down" and "the sea-horse taken in drink." It would be difficult to carry out his prescription for protection against miscarriage, however. Since sea hares are hermaphrodites, there are no male or female specimens!

The Swedish ecclesiastic Olaus Magnus gave this fanciful description in the sixteenth century: "The Sea Hare is found to be of divers kinds in the ocean, but so soon as he is caught, only because he is suspected to be venemous, how like so ever he is to a Hare, he is let loose again. He hath four fins behind his head, two whose motion is all the length of the fish, and they are long, like to a hare's ears, and two again, whose motion is from the back, to the depth of the fishes belly, wherewith he raiseth up the weight of his head."

Still another description was given by Charles Darwin when he visited the Cape Verde Islands in 1832: "A large *Aplysia* is very common. This sea-slug is about five inches long; and is of a dirty-yellowish color, veined with purple. On each side of the lower surface, or foot, there is a broad membrane, which appears sometimes to act as a ventilator, in causing a current of water to flow over the dorsal branchiae, or lungs. It feeds on the delicate sea-weeds which grow among the stones in muddy and shallow water; and I found in its stomach several small pebbles, as in the gizzard of a bird. This slug, when disturbed, emits a very fine purplish-red fluid, which stains the water for the space of a foot around. Besides this means of defense, an acrid secretion, which is spread over its body, causes a sharp, stinging sensation, similar to that produced by the . . . Portuguese man-of-war."

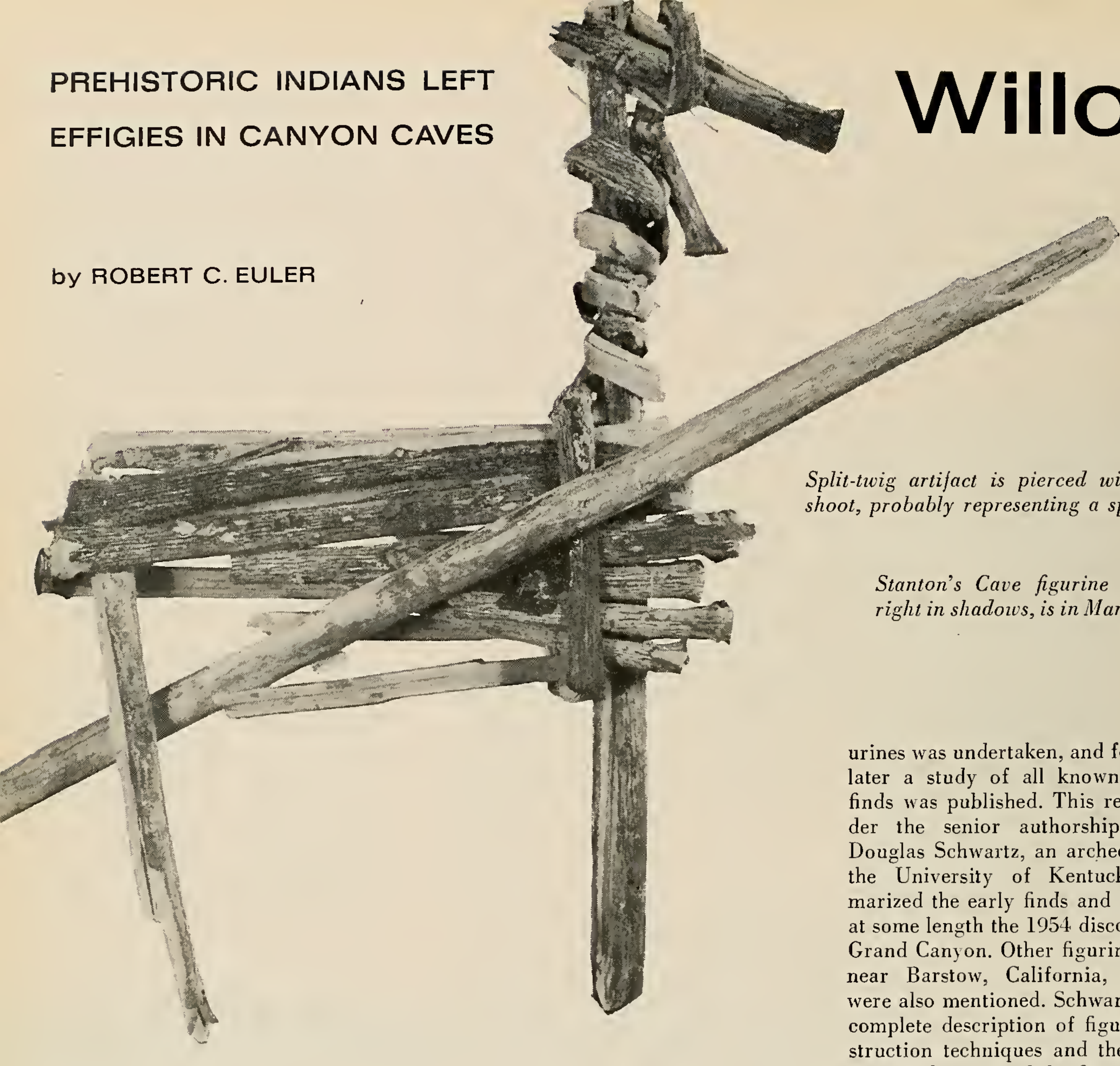
This last description, except perhaps for Darwin's mention of the sting's virulence, is in accord with modern studies on the sea hare. One of the problems investigators continue to face, of course, is taxonomic; there are many differences between individuals of a species found in several locations, and many similarities among different species. Consequently, it is difficult to distinguish them.



PREHISTORIC INDIANS LEFT EFFIGIES IN CANYON CAVES

Willow

by ROBERT C. EULER



Split-twig artifact is pierced with a shoot, probably representing a spear.

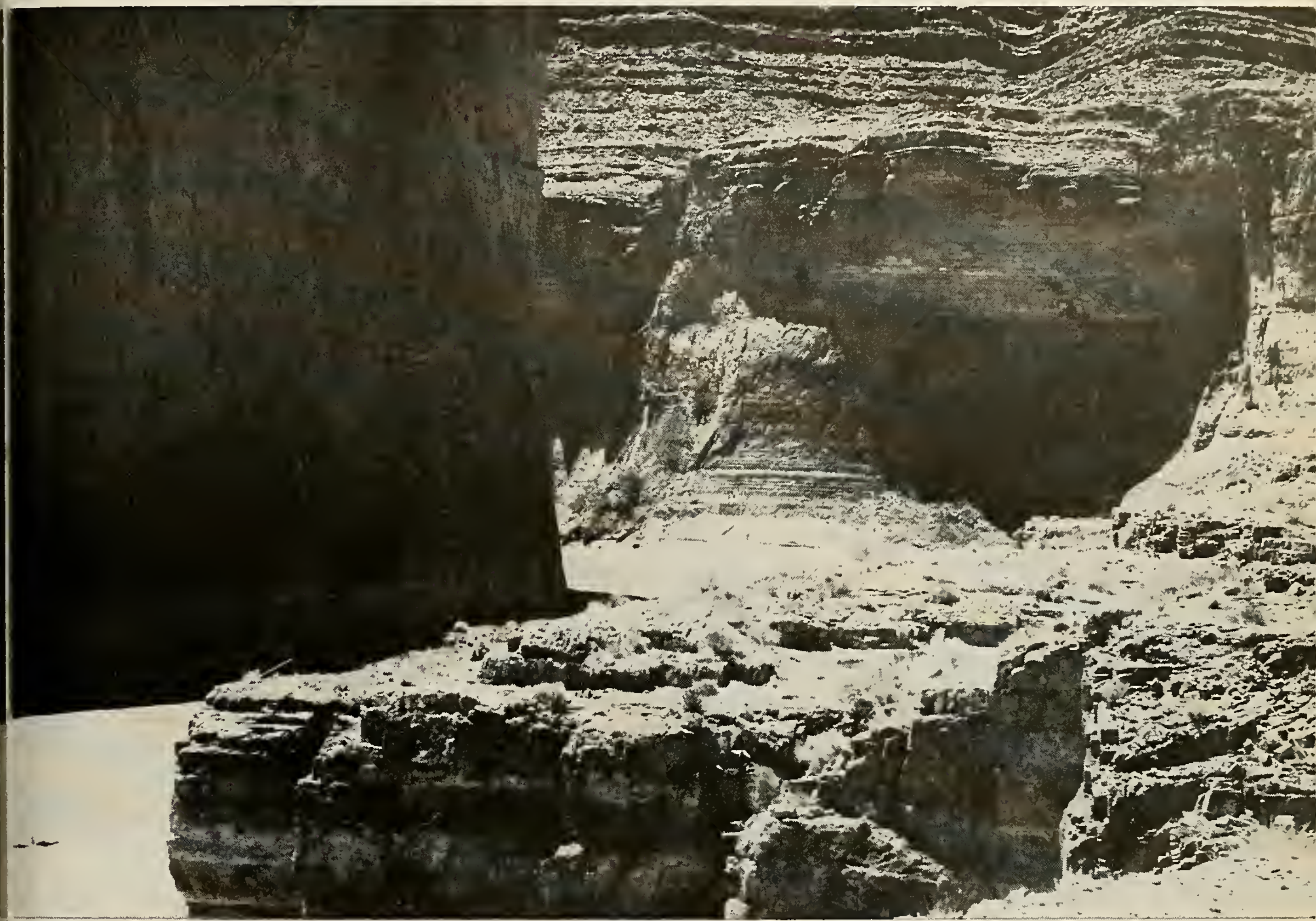
Stanton's Cave figurine site, to right in shadows, is in Marble Can

Split-twig figurines, tiny artifacts made of willow withes from one to eight inches long, were first discovered in 1933 in Arizona's Grand Canyon near a northern-rim tributary of the Colorado River. The next year, fifteen similar figurines were recovered from a cave in Sycamore Canyon, eighty miles south of Grand Canyon, and still another find was made in Marble Canyon in Stanton's Cave, about thirty miles up the Colorado from Grand Canyon National Park. However, none of the early finds engendered more than passing curiosity. The products—now known to have been made by prehistoric Indian hunters—were at first thought to be of recent origin. Most of them had been found on the surface of cave floors and were hardly dust covered; some were still standing erect.

In 1935, S.M. Wheeler, archeologist for the Nevada State Park Commission, uncovered more twig figurines in Etna Cave, about one hundred miles northeast of Las Vegas. He reported that his specimens were in association with artifacts of Basket Maker III origin—dating them between A.D. 500 and 700—as well as with "horse dung and dart-points of Gypsum Cave type" of perhaps 10,000 years ago. But he gave no detailed stratigraphic data, and the precise cultural and chronological relationships of the Etna Cave figurines remained obscure.

Although figurines were then discovered in Stanton's Cave in 1939, widespread interest in them was not manifest until 1954, when two speleologists came upon three additional sites in Grand Canyon. Still no definite cultural correlations were found, but a detailed analysis of the technique of manufacturing the figurines was undertaken, and four year later a study of all known figurin finds was published. This report, un der the senior authorship of Dr Douglas Schwartz, an archeologist a the University of Kentucky, sum marized the early finds and discussed at some length the 1954 discoveries in Grand Canyon. Other figurines found near Barstow, California, in 195(were also mentioned. Schwartz gave a complete description of figurine con struction techniques and their varia tions and presented the first radiocar bon dates for the artifacts. One speci men, processed at the University o Michigan, yielded an age of 1580 B.C. ± 300. Another, submitted to the Uni versity of Arizona for testing, was dated 1150 B.C. ± 110. In view of these surprisingly early dates and the fact that many of the specimens seemed to have been ritually pierced by tiny wooden spears, Schwartz suggested that "they may have been part of the widespread Desert Culture" (a hypothesis that is now supported) and were magico-religious in function. The Desert Culture was a way of life followed by many prehistoric Indians of the western desert who lived in areas from the Columbia River drainage in the north, through the Great Basin of Nevada and Utah, and south into western Mexico. The age of this culture, based largely upon radiocarbon dates, is from 7000-6000 to 2000 B.C., and somewhat later in some places. It

Figurines from Arizona



as been characterized by cave or ock shelter habitations, hunting and athering of wild foodstuffs, and man-'acture of small projectile points, flat illing stones, and twined basketry, to st but a few major attributes.

The announcement of radiocarbon ates and Schwartz' hypothesis as to e cultural affinities of the well-pre-rved effigies were greeted with mild credulity by some archeologists. ating organic material by counting e rate of disintegration of its origi-l radioactive carbon content still ft room for error. In addition, hile the Desert Culture manifesta-ons were known in the southwestern nited States, they had not, as yet, en definitely associated in what ap-ared to be the heartland of the fig-ine complex, the Grand Canyon. More important, perhaps, was that the figurines had never been contextually found in excavated cave sites known definitely to have been occupied by Desert Culture peoples.

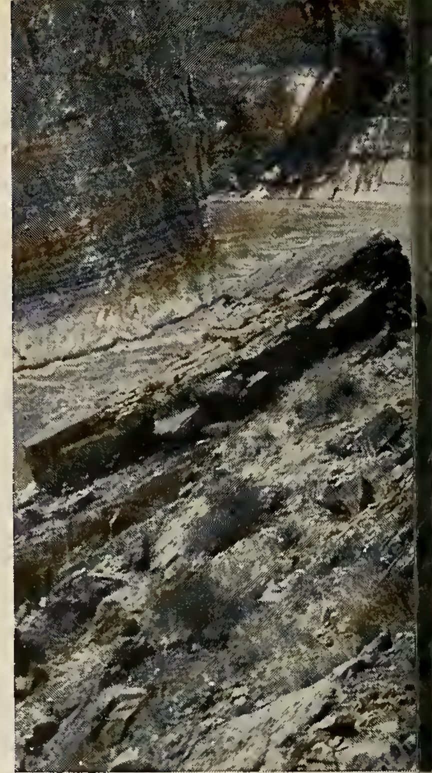
So alternative ideas were proposed —or supposed. Perhaps the figurines had been made by more recent, historic, Indian inhabitants of Grand Canyon. The Walapai and Havasupai were known to have occupied the south rim for some centuries before the opening of the historic period, and the Southern Paiute had a similar location on the north rim. Earlier, beginning perhaps as early as A.D. 700, small groups of prehistoric Pueblo Indians had infiltrated the recesses of the canyons in search of game or wild plants and to raise small crops of corn, beans, and squash. Dozens of sites, characterized by small masonry pueblos and cliff dwellings, were occupied in the eleventh and twelfth centuries. These Indians farmed alluvial plots along the river or in tributary canyons, and hunted in what to us seem almost inaccessible locations. In later centuries, the Hopi Indians sometimes ventured into the Grand Canyon in their quest for salt.

However, all search of archeological and ethnological literature proved futile in effecting associations between any of these peoples and the figurines. By 1963 additional discoveries had not been made, and the radiocarbon dates were not, in themselves, completely accepted. Archeologists still were unable to demonstrate indisputable relationships of the effigies with any known cultural manifestation, early or late, prehistoric or historic, and the only empirical knowledge about them was how the artifacts had been made, and perhaps why.

The technique of manufacture was relatively simple (*see diagram, below*). A green willow twig first was cut to a length of two to four feet, split along most of its length. and the unsplit lower portion was bent to form the hind leg and back. One segment of the split branch was then bent down and up to form the front leg. The end of this same piece was again bent and positioned to make the neck. Then the upper split segment was wrapped around front and rear legs to construct the animal's body. Following this, the neck splint was angled to form the nose, after which it was bent back toward the neck, wrapped over the nose to complete the head, and then down along the neck to be wrapped under the body behind the front legs. This thickened the neck and provided stability for the body. The remainder of this segment then came back over the head to end in a spiral wrapping around the neck, and the end was tucked into the base of the neck to complete the figure. While this seems to be a most ingenious, if not complicated, manufacture, with a little practice one can produce a figurine in five or ten minutes.

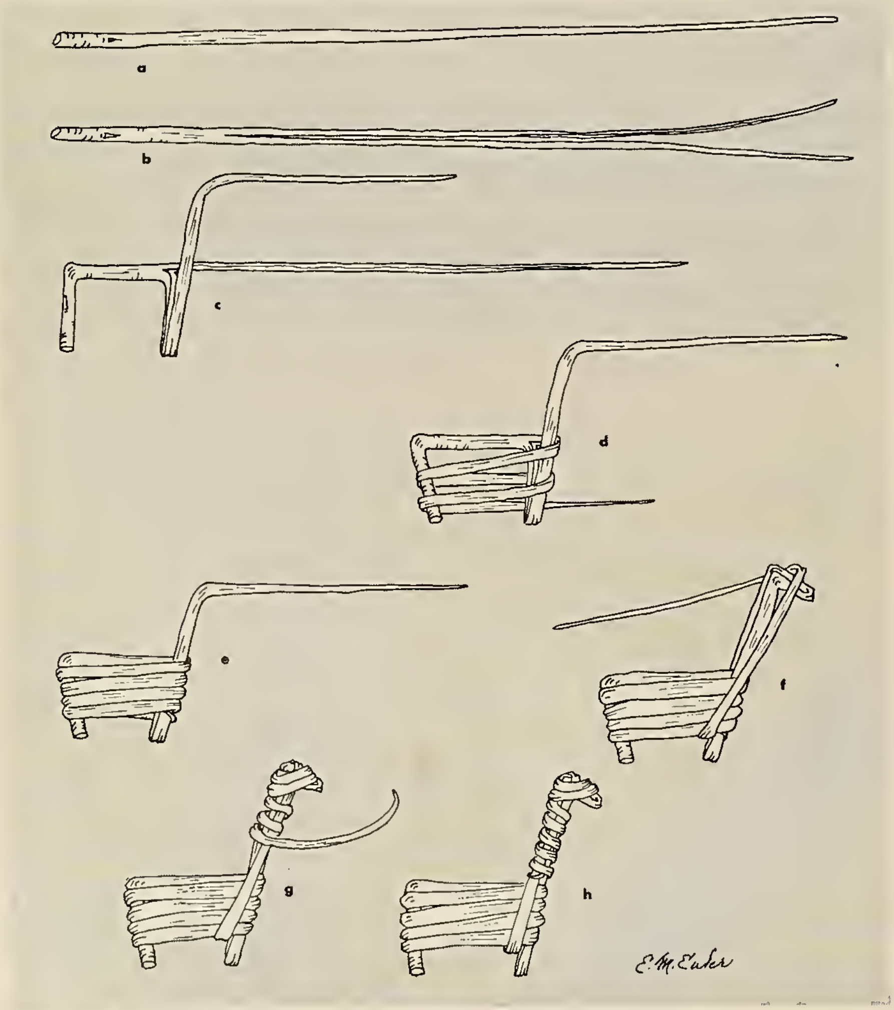
Considerable variation has been recorded in the size of the figurines. Some are only one inch long, while others range up to eight inches. The size of the completed effigy and the number of body wraps are entirely a function of the length of the willow shoot selected. A few specimens have what seem to be hornlike appendages on the head, and on an occasional figure an additional grass body wrapping has been noted. Frequently the bodies are pierced with unsplit twigs, probably representing miniature spears.

It was the spears that gave rise to the



suggestion that the figures were us
in religious rites of imitative magi
One can visualize a small group of pr
historic hunters, before taking to t
trail in search of game, gatheri
some green willow withes and going
an isolated, uninhabited cave to ma
effigies of the animals they soug
(perhaps deer or mountain sheep
and symbolically piercing them wi
spears. They then placed the tiny an
mals in caches under large rocks or
crevices in the cave floor (the plac
where they have usually been found

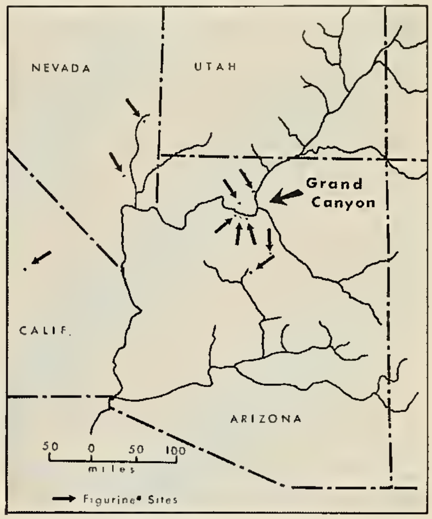
During the past several years,



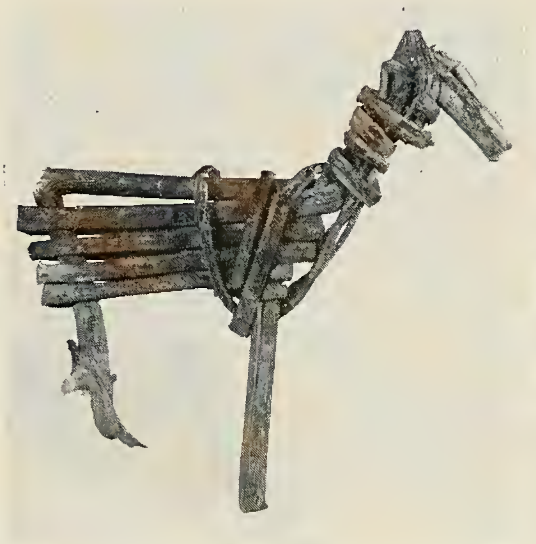
Green twig was first cut to length of two to four feet (a), *then split* (b) *and bent into the form of an animal by means of steps* c *to* h. *Some were given hornlike appendages, as one at right; others were wrapped in grass.*

Figurines predate these nearby pueblo structures by more than 4,000 years.

Most sites where figurines were found are near Colorado River tributaries.



ave carried on a search for additional lata on the split-twig figurines as part f a broader archeological and ethno- ogical study of the Grand Canyon and ts environs, in an attempt to recon- truct as much as possible of the cul- ural history of the area. During these xplorations, I looked for additional plit-twig figurine sites, but found one until the summer of 1963. Then, xploring in a small helicopter with)r. Alan Olson of the University of)enver and the pilot, Frank Garvin, revisited and made a more intensive xamination of Stanton's Cave. This huge limestone grotto, extending more than four hundred feet into the wall of the inner gorge of Marble Canyon, is today occupied primarily by bats. The entrance to the cave is about one hundred feet above the river, and near it a large spring of cold, fresh water gushes from a cleft in the cliff. This is Vasey's Paradise, named in 1869 by the one-armed, Civil War Major John Wesley Powell, one of Grand Canyon's first explorers, in honor of a botanist who had accompanied him on an earlier trip through the Colorado Rockies. A tiny masonry ruin is also in the vicinity, marked by broken pottery of the Southern Paiute. Just upstream on a narrow bench there are several prehistoric pueblo structures, including a small cliff dwelling that must have been occupied around A.D. 1100-1150. In Stanton's Cave itself, however, we found no sign of human utilization except for caches of split-twig figurines hidden from view under tremendous rocks that had once fallen from the cave roof. We found three such caches, and before removing the effigies carefully sealed them in polyethylene bags to



Effigies, often hardly dust covered, were discovered on the floors of caves.

Well-made figure measures five inches long. Size depends on length of twig.

protect them from accidental contamination by airborne radioactivity. In all, ten complete and ten fragmentary specimens were found, together with bundles of split twigs.

In an effort to ascertain the accuracy of the dates obtained by Dr. Schwartz, I submitted one of these figurines to the radiocarbon dating laboratory at the University of California at Los Angeles. Some archeologists had suspected that his dates were too early, because the figurines might have been contaminated by older carbonates emanating from the limestone of the caves in which they had been found. However, the laboratory subjected this figurine to a dilute hydrochloric acid rinse to remove any such impurity before dating. After a carefully controlled procedure, the California laboratory announced an age of 2145 B.C. ± 100, the earliest date yet recorded.

Meanwhile, Dr. Olson was conducting independent archeological excavations for the Museum of Northern Arizona in a small limestone rock shelter near Walnut Canyon National Monument, a few miles east of Flagstaff, Arizona. There he discovered eight additional figurines and twenty-three fragments. However, despite carefully controlled excavation techniques, the depth of the rock shelter deposit was too shallow to permit any valid observations as to the cultural associations of the artifacts. Two of the figurines from this site also were radiocarbon dated, one with a resultant date of 1550 B.C. ± 100, and the other determined to be 1930 B.C. ± 90. Thus, these three new dates generally confirm earlier determinations and demonstrate that the earliest known human utilization of Grand Canyon and Walnut Canyon was in the range of 3,000 to 4,000 years ago—some 2,000 years earlier than was thought previously.

At present, nothing has been discovered that would definitely indicate the cultural affinities of the figurine makers. Since people normally do not live in places that are used ritualistically, such associations may never be forthcoming. However, with such an early range of radiocarbon dates, th[e] historic Walapai, Havasupai, an[d] Paiute can be eliminated, as can th[e] prehistoric Pueblo Indians, who[se] cultures were not extant that long ag[o]. The dates do, however, fall within th[e] known chronological span of sever[al] Desert Culture components (as D[r.] Schwartz indicated in his 1958 r[e]port), and further investigations hav[e] turned in this hypothetical direction.

Coincidental to these investig[a]tions, what may prove to be a signifi[i]cant link in the story of early man i[n] northern Arizona was discovered i[n] the early spring of 1964. On the sum[]mit and slopes of Red Butte, a prom[i]nent, lava-capped sandstone promon[]tory a few miles south of Grand Can[]yon, archeologists found projectil[e] points and other stone tools of an earl[y] type ascribable to the Pinto Complex. This was a Desert Culture componen[t] first recognized in Pinto Basin, nea[r] Newberry Cave in California's Mojav[e] Desert, and since reported from a num[]ber of widely separated localities i[n] the western desert. The most diagnos[]tic artifact type of the semi-nomadic hunting-and-gathering Pinto Cultur[e] is the small, indented, base projectil[e] point, and while collections of thes[e] tools from the western desert hav[e] never been thoroughly studied nor in[]controvertibly dated, it would appea[r] that an age of 3,000 to 4,000 years ag[o] would not be out of order.

It must be emphasized that split twig figurines have not been found anywhere in direct association with Pinto materials. But because of the presence of Pinto sites near caves con[]taining figurines (such as those in Grand Canyon and in Newberry Cave in California) and because of the probability that the Pinto cultura[l] time range spans the dates of the fig[]urines, it is conceivable that some Pinto hunters may have been respon[]sible for their manufacture. This con[]clusion is, however, but a working archeological hypothesis to be tested in future field investigations. The Grand Canyon figurine complex is only one of many problems of human culture-history, the solutions to which may never completely be ascertained.

Stanton's Cave opening, photographed from helicopter, is one hundred feet above Colorado River. Cave extends four hundred feet into wall of gorge.

This part of Marble Canyon is 30 m[iles] from Grand Canyon National P[ark]

About the Authors

Hugh H. Waesche and Dallas L. Peck, authors of the article on volcanoes, are geologists with the U.S. Geological Survey. Mr. Waesche has been a member of the Chief Geologist's staff for five years, and during 1962-63 was one of the principal contributors to the U.S.-Japan Cooperative Science Program. Mr. Peck joined the Survey in 1954, and has concentrated in the fields of volcanism and igneous phenomena. Both authors have been members of the Hawaiian Volcano Observatory research team—Mr. Waesche from 1934 to 1941, and Mr. Peck for the past two years.

Dale Whitney, who wrote and took the pictures for the Dacus fly article, is a free-lance photographer and writer who often specializes in medical and scientific stories. She has traveled on assignment for the World Health Organization.

Part II of "Locomotion Without Limbs" concludes an article on snakes begun in the February issue. The author, Dr. Carl Gans, is Associate Professor of Biology at the State University of New York at Buffalo and a Research Associate at The American Museum.

Dr. J. D. Palmer, whose research specialty is the study of biological rhythms in algae, crabs, and birds, is author of "How a Bird Tells the Time of Day." He was Assistant Professor of Biology at the University of Illinois from 1961 to 1963, and has been Assistant Professor of Biology at New York University since 1964. During 1963-64 he was a National Science Foundation Postdoctoral Fellow at the University of Bristol, England. He is a corporation member of the Marine Biological Laboratory at Woods Hole, Mass., and has been a summer researcher there for seven years.

Dr. Fred D. Ayres, author of "Giants of the Puna," has been a member of four mountaineering expeditions to Peru, and in 1963 held a Fulbright lectureship in physical chemistry at the University of Huamanga in Ayacucho, Peru. He is Associate Professor of Chemistry at Reed College, Portland, Oregon.

David Linton, who wrote "Grazing Mollusks in the Weeds," has been a contributing editor to Natural History for many years. He is an editor at W. B. Saunders Co. in Philadelphia.

"Willow Figurines from Arizona" was written by Dr. Robert C. Euler, Associate Professor and Chairman of the Department of Anthropology at the University of Utah, Salt Lake City. Dr. Euler specializes in the archeology and ethnology of the southwestern United States, and has conducted an archeological survey of Grand Canyon and Marble Canyon over the past five years. In 1962-63 he made a study of Southern Paiute archeology and ethnohistory.

PORTRAITS IN SCIENCE

Renaissance botanist

By Trevor Robinson

At the time of Linnaeus (1707-1778), botany was already recognizable as a science. Indeed, it had been a science for a longer period before his time than it has been from Linnaeus to the present. Books have been written about what science is or is not; but if its definition rests largely on the accumulation and organization of observations of nature that are studied for their own intrinsic interest, then to a few people botany became a science about the year 1500. Thus, the enormously important contributions made by Linnaeus rested on 250 years of patient and inspired observations, insights, and systems.

There are frequent misconceptions about these early years of botanical study during which science gradually disentangled itself from folklore and empirical knowledge. The disentanglement is by no means complete even today. The proportion of science to myth seems to have increased over the years, but we tend to assume that today all is science, whereas all was myth or ignorance a few hundred years ago. It is, therefore, exciting to discover that centuries ago there were observers and systematizers whose insights we can still admire.

In botany, specifically, binomial nomenclature and the understanding of plant relationships were at least partially appreciated, more than two hundred years before Linnaeus, by Valerius Cordus, the botanical genius of the Renaissance. Cordus would not have spoken of genera and species the way we do, but his nomenclature has a modern ring to it. In arranging plants for discussion he often grouped together species that we now know are related, although previously they had never been so recognized.

The Renaissance means different things to different people; in a sense there was not a single Renaissance, but several that flowered in different parts of Europe at different times and emphasized different aspects of culture. One usually thinks first of the artistic and literary renaissance in Italy, but fully as exciting was the scientific renaissance that also spread across Europe: Aristotle, Galen, Ptolemy, and many others were studied and questioned from a scientific, rather than from a purely literary or philosophical, point of view. All of the sciences had their private little renaissances to which more or less precise dates can be attached. For the rebirths of anatomy and astronomy we think of the *De humani corporis fabrica* of Vesalius and the *De revolutionibus orbium coelestium* of Copernicus, both published in 1543. Botany, too, had its rebirth at nearly the same time.

All through the Middle Ages, the name of Dioscorides was synonymous with botany. Dioscorides, who lived in the second half of the first century, about one hundred years before Galen, was also a physician, but his interest extended to materia medica rather than to anatomy. A majority of early medicines were made from plants, and it was necessary for him to prepare accurate descriptions so that plants could be identified and used by practitioners. The *Materia Medica* of Dioscorides, then, was the standard book on botany for something like fourteen hundred years. To study plants meant to study Dioscorides, and when the botanical renaissance began—in central Germany—it began only as a revival of interest in Dioscorides, in an attempt to apply his descriptions of Mediterranean flora to the vegetation of northern Europe.

Sixteenth-Century Herbals

The illustrated herbal of Otto Brunfels, published in 1536, was the first really important attempt in this direction. It stressed the medical uses of plants and was primarily a compilation from ancient authorities, although its

Valerius Cordus

beautiful and accurate woodcuts were a valuable innovation. The second of the important German herbals appeared three years later and was based more on original observations. Its author, Jerome Bock, gave full and accurate descriptions of many native plants that he had observed. Then in 1542 *De historia stirpium* of Leonhard Fuchs appeared, consisting of two volumes with superb plates.

Finally the youngest of the great herbalists arrived on the scene—Valerius Cordus of Simesusa, in Hesse. His father was Euricius Cordus, a physician, naturalist, poet, and respected independent scholar who had published a short book called the *Botanologicon*, which, perhaps, pointed the way for his son's development. The book was a discussion of the identification of native German plants mentioned by Dioscorides, and to Euricius belongs the honor of first pointing out previous identification errors.

Valerius was born on February 18. 1515. He attended the best schools of Germany, including the University of Marburg, where his father was professor of medicine. and when he was about nineteen he spent some time in Leipzig with his maternal uncle, the pharmacist Johannes Ralla. During this year or so devoted to learning pharmacy with Ralla (about 1534), he prepared his first book. His uncle had asked him. perhaps only as an educational exercise, to assemble and comment on selected pharmaceutical preparations. The result was so impressive that Ralla later showed it to his professional acquaintances, and on the advice of Caspar Pfruend, the leading pharmacist of Wittenberg, the book was presented to the Senate of Nuremberg. In 1543, ten years after Cordus had prepared it, this body gave it official recognition and prescribed its use by all the pharmacists of the city. Other similar collections were in existence, but none was given such governmental sanction.

Pharmaceutical Ingredients

The Cordus *Dispensatorium* followed the guiding pharmaceutical principle of the times: "If one drug is good, twenty will be twenty times better." Fifty or sixty ingredients in a preparation were not unusual, including almonds, mace, ginger, licorice, fennel. myrrh, pepper, pyrethrum, musk, and red coral. Such conglomerations were recommended for curing dizziness, clearing the eyes, cleansing the palate, relieving toothaches and asthma, allaying weakness and pain of the stomach and liver, restraining malarial fevers, and acting as preventives for many diseases.

Cordus, of course, was acting as a compiler rather than as an inventor. His virtue lay in the intelligent discussions of the individual plants. For example, following a recipe calling for cassia fistula, he commented that true cassia was a black kernel that purges bile, while the species referred to was an aromatic, woody plant similar to cinnamon. This particular problem is still with us; today the name cassia is being used for these two entirely different kinds of plants.

Meanwhile, under the guidance of his uncle, Cordus soon learned the extraction and distillation procedures required to compound drugs. In a short monograph attributed to him, *On Artificial Extractions*, several such processes are described, including the manufacture of sulphuric acid. The most interesting thing about this work is that it contains the first published directions for preparing ethyl ether. Ether may have been known somewhat earlier by Paracelsus, but it was Cordus who first described its preparation. The product itself, which he called "sweet oil of vitriol," was a long way from being pure ether, but ether was certainly a component. Whatever its merits, the mixture continued to be used as an anodyne and tranquilizer under many names. In fact, as "Compound Ether Spirit," it appeared in the 1950 edition of the *Dispensatory of the United States of America*. This is a long history for any drug, and perhaps it entitles Cordus to recognition as the first person to synthesize a tranquilizer.

In about 1538 Cordus left Leipzig to go to the University of Wittenberg—Martin Luther's university and the intellectual center of the Reformation. Peculiarly, all the German herbalists of the time seemed to be ardent espousers of the

eformed faith, and Cordus was no ex-eption. At Wittenberg, Philipp Mel-nchthon, leading theologian of the Re-ırmation, was one of Cordus' professors. ſe taught Greek, and among the texts e expounded was a book on poisons nd antidotes written in verse by Nican-er of Colophon. Melanchthon's interest 'ould naturally have been literary, ather than scientific, but nevertheless it 'as like hearing a modern professor of terature discussing the *United States 'harmacopoeia* in his classes. This dem-nstrates only that the revived attention) the ancient sciences began as a liter-ry, humanistic interest, and was trans-ıuted into science only by the work of ıen like Cordus.

Cordus finished his studies and at the ame time prepared his *Annotations on)ioscorides*, which was not published ntil after his death. Every medical chool of the time had lectures on the *Aateria Medica* of Dioscorides, and for hree terms at Wittenberg these lectures vere delivered by Cordus. To the usual iterary and pedantic discussion, how-ver, he added his own observations on iving plants, and like his father, he urther exposed the error of expecting to ınd in Germany all the southern plants lescribed by Dioscorides. Of a plant)ioscorides called *Ruscus*, he wrote:

"When a certain person described to me a place in Germany where *Ruscus* grew copiously, I set out for there so that I might see the living plant. I did not find *Ruscus* at all but another herb with very soft leaves like grass, whose shape could not differ more from the leaves of *Ruscus*, although the roots are similar."

His recognition of the need for accurate plant descriptions is reflected in his wryly amusing comment regarding the *Marum* of Dioscorides:

"*Marum* was an herb formerly known to everyone. Therefore its form was not described. Today, as a result, it is not known to anyone."

Evidently Cordus later discovered *Marum* while on a journey to Italy, and he then described it as a plant intermediate in form between those we now know as marjoram and oregano.

Annotations deals not only with higher plants but with many other materials used in medicine. It discusses lichens, observing that their peculiar reproductive structures are not analogous to the flowers, stems, or seeds of other plants. It also includes animal products such as ivory, eggs, butter, and various dried insects. Mineral products, such as bitumen, naphtha, metals, and amber, are described at some length, even though they were less important for medicinal purposes than for use in the mechanic arts.

Like all of his other writings, except the *Dispensatorium*, these annotations were not published in his lifetime. In fact, we owe their survival to a notebook kept by one of his students, Johannes Aurifaber, private secretary to Martin Luther. His transcription of the Cordus lectures on Dioscorides came to the hand of Konrad von Gesner, the great Swiss bibliographer, who published it along with other works of Cordus in 1561.

Botanical Field Trips

FRIENDS of Valerius left admiring descriptions of him, telling of the enthusiastic exertions he made in search of knowledge. With Wittenberg as his base, he sometimes undertook laborious pilgrimages throughout Germany and neighboring regions to find a single plant. As one friend wrote: "He entered bristling wooded mountains, conquered the highest peaks, and thrust himself into the deepest caverns. With the greatest diligence he investigated what things were produced in these places, hitherto observed by very few people."

Cordus was an early enthusiast of the botanical field trip, and frequently took students with him on his expeditions. In 1541, Pierre Belon, a young French naturalist, and other students made a

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four-month trip with Cordus through Saxony, Pomerania, and Bohemia, where they collected botanical specimens and also visited mines—including the most famous of the time in Joachimsthal, Bohemia. Here Georg Agricola, the greatest mining authority of his day, and Cordus became fast friends and collaborators. Both men, although trained as physicians, were interested in all of nature. Cordus, primarily a botanist, wrote intelligently on minerals, and Agricola, known for his work in mining, collected and thought about plants.

The greatest book prepared by Cordus during his short career was the five-part *Historia Stirpium*. Here he was tied to no classical models. He looked at plants with a fresh eye and described them in an orderly, accurate fashion so that four hundred years later there is seldom any question about what plants he meant. Nearly all of them have been conclusively identified by the British botanist T. A. Sprague. Of the approximately five hundred plants included, over 10 per cent had never before been described in any herbal.

As an example of the detailed clarity in his work, consider his treatment of Indian corn, a recent import to Europe. Cordus, like his contemporaries, was confused as to the origin of this plant, which was thought by many to have been a native of Turkey, hence the adjective "Bactrian."

"Bactrian or Indian wheat is a summer grain. It has a stalk 4½ feet high, as thick as a finger, jointed, solid, and filled with a spongy pith. Its leaves are for the most part more than a foot long, three or four inches broad, full of veins and similar to those of reeds. At the apex of the stalk it bears heads nine inches long, usually slender and loose, similar to the heads of olyra [rye] and flowering in the same way. The heads, sometimes 15, 20, or 30 of them, dry up after the blossoms are shed and produce no seed. The ears which really produce fruit come out lower down, from the joints of the stalk, sometimes three or four of them but only one to each joint. These are nine or more inches long, thick enough to fill the hand, and covered with many leafy husks which are rolled up so very tightly that no water can get through to spoil the ears. When the ears reach the proper size, they produce instead of flowers numerous long, shiny hairs, as it were, which hang over from the narrow tip and are attached individually to the seeds. When the husk has been drawn back and the seeds have dried, they are seen to be the size of large peas, without glumes or awns, extended longitudinally in eight or ten rows. They encircle on all sides a spon[gy] pith and are so tightly pressed togeth[e]r that they are squeezed into an angu[la]r shape. . . . They have a saffron or g[o]l[d] color, and a peculiar variety occurs w[ith] reddish or blackish grains.

"The plant bears many oblique, [fi]brous roots to which are also added s[ev]eral props which come out on all sid[es] from the lowest joints and are sent do[wn] into the earth so that the stalk is su[p]ported when blown by the wind. . . . T[he] seeds have a taste that is milder a[nd] sweeter than other grains."

Modern Taxonomy Foreshadowe[d]

Throughout the book Cordus [de]scribed the form of a plant and a[lso] recorded something about its life histo[ry] and ecology. His extremely careful [ob]servations and descriptions of types [of] flowers perhaps led him to a foreshado[w]ing of modern taxonomy based on flo[ral] structure. Although he kept the ancie[nt] broad division of all specimens in[to] woody plants and herbs, there is go[od] reason to think that he perceived re[la]tionships that had not been noticed b[e]fore. Thus, he placed the lupines and t[he] licorice plant with the legumes, where[as] the ancients had placed only edible bea[ns] and peas in that category. In some r[e]spects he went too far in his reliance [on] flowers, however, placing together plan[ts] that are now considered unrelated.

Cordus did not provide illustratio[ns] for the *Historia Stirpium*, perhaps b[e]cause he did not get around to assem[]bling them, or perhaps because he co[n]sidered them unnecessary in light of h[is] detailed verbal descriptions. When th[e] book was published posthumously, ho[w]ever, von Gesner added illustrations [he] had selected (sometimes incorrectly) from several other German herbals.

At the age of twenty-eight Cordus a[p]parently believed that it was time for hi[m] to explore fields other than the Germa[n] flora. It was natural that a botanist wh[o] had mastered the work of Dioscorid[es] and other botanical writers of the Med[i]terranean regions should wish to see wit[h] his own eyes the plants they had d[e]scribed. In addition, many dried plan[t] parts were imported into Germany fro[m] the south for pharmaceutical purpose[s] and Cordus wished to see the livin[g] plants from which these leaves, fruit[s] and roots came. In the fall of 1543, h[e] and several companions set out for Ital[y]. They stopped at the University of Padu[a], the University of Ferrara, and the Un[i]versity of Bologna, where Luca Ghin[i], the most renowned botanist of the tim[e] was professor. From Bologna they tra[v]eled toward Siena, making many sid[e] trips into the countryside in search [of] plants described by Pliny and other an[]cient authors. Hieronymus Schreiber, [a] friend of Cordus', described how thes[e] northerners "tramped through arduou[s]

ıntains, along the seashore, and in er places most exposed to the sun."

Attack of Fever

(NE evening, however, after arriving at an inn, Cordus became ill. His ·nds attributed his fever to a horse's k, but it was probably abetted by his ·nuous work in the Italian heat and, haps, bad food at the inn. They finally ried him to Rome, where they had dly found lodgings before they, too, ·e attacked by the fever. Schreiber ar·d in Rome to find all three of his ·nds desperately ill. He was received h great relief by the sick men, and ·dus, who was most gravely ill, weak·d himself still more by telling about journey, the rare plants they had nd, and the city of Rome.

Even so, Cordus did improve slowly about two weeks, and his companions overed completely. In fact they conıplated making a journey to Naples. ey debated about leaving Cordus, but medical care provided for him ·med sufficient — two Italian doctors l no fewer than five German ones. ·ely Valerius could not have been left better hands, and so his friends de·ted for the south.

On the day after they left, however, lerius suffered such a grave relapse t his doctors immediately despaired l wanted him to confess and take the man Catholic form of Communion— ich he refused. One of the Germans ated a German priest, but even he re·ed to administer the rite in the Re·med manner. Valerius reaffirmed that would do without it altogether. The urch authorities threatened that his ly would be hurled into the Tiber if he l not receive proper Communion, but doctors concealed this danger from rdus. He was sinking rapidly, and en he became unconscious, they called another priest who administered exme unction. Only by this concession ıld a tomb be procured for him.

Finally," wrote Schreiber, "four hours er sunset on September 25th [1544] er two or three strong breaths he ex·ed in their hands to the great sorrow l grief of all." He was 29 years old.

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is list details the photographer, artist, other source of illustrations, by page.

'ER—Margaret C. lish
21—U.S. Navy
-AMNH
-Margaret C. English
-top, Merel S. Sager; tom, P. E. Schulz
27—U.S. Geological vey
29—Margaret C. lish
35—Dale Whitney, ck Star
37—Carl Gans
39—AMNH after Gans
41—New York Zoologi- Society except dia- n, AMNH after Gans
-Francis P. Johnson, Florida State News Bureau except bottom right, Grant Haist
43—Robert Fitch Smith
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47—AMNH
48—Albert G. Gilbert and The Bettmann Archive
50-53—AMNH after John D. Palmer
54-57—Fred D. Ayres
58-61—David Linton
62-67—Robert C. Euler except 64—bottom left, E. M. Euler; 65—top right, AMNH after Robert C. Euler
69—National Library of Medicine

Suggested Additional Reading

VOLCANOES TELL SECRETS IN HAWAII

HOW VOLCANOES GROW. J. P. Eaton and K. J. Murata. *Science*, Vol. 132, No. 3432, pages 925-938. 1960.

IGNEOUS AND METAMORPHIC PETROLOGY. F. J. Turner and J. Verhoogen. McGraw-Hill, N.Y., 1960.

THE 1961 ERUPTION OF KILAUEA VOLCANO, HAWAII. D. H. Richter, W. V. Ault, J. P. Eaton, and J. G. Moore. U.S. Geological Survey Professional Paper 474-D, 1964.

STERILE FLIES USED TO COMBAT DACUS

ATOMIC ENERGY TO CONTROL INSECTS. L. D. Christenson. *1962 Yearbook of Agriculture*, U.S. Dept. of Agriculture, Yearbook Separate No. 3186.

A NEW ERA IN PEST CONTROL: THE STERILITY PRINCIPLE. E. F. Knipling. *Agricultural Science Review*, U.S. Dept. of Agriculture, Fall 1963.

STERILE-MALE METHOD OF POPULATION CONTROL. E. F. Knipling. *Science*, October 9, 1959, pages 902-904.

LOCOMOTION WITHOUT LIMBS

HOW ANIMALS MOVE. J. Gray. University Press, Cambridge, 1953.

TERRESTRIAL LOCOMOTION WITHOUT LIMBS. C. Gans. *American Zoologist*, Vol. 4, No. 2, pages 167-182, 1962.

HOW A BIRD TELLS THE TIME OF DAY

CIRCADIAN CLOCKS. J. Aschoff. North-Holland Publishing Co., Amsterdam, 1965.

THE PHYSIOLOGICAL CLOCK. E. Bunning. Springer-Verlag, Berlin, 1964.

THE PHYSIOLOGY OF DIURNAL RHYTHMS. J. E. Harker. University Press, Cambridge, 1964.

GIANTS OF THE PUNA

PUYA, THE PINEAPPLE'S ANDEAN ANCESTOR. M. B. Foster. *National Geographic*, Vol. 98, October, 1950, pages 463-480.

GRAZING MOLLUSKS IN THE WEEDS

THE LOWER ANIMALS. R. Buchsbaum and L. J. Milne. Doubleday & Co., Inc., Garden City, 1962.

WILLOW FIGURINES FROM ARIZONA

SPLIT-TWIG FIGURINES IN THE GRAND CANYON. D. W. Schwartz and others. *American Antiquity*, Vol. 23, pages 264-274, 1958.

THE DESERT WEST. Chapter by J. D. Jennings in PREHISTORIC MAN IN THE NEW WORLD, edited by J. D. Jennings and E. Norbeck. University of Chicago Press, 1964.

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ARTICLES

DEPARTMENTS

COVER: Of all known Maya archeological sites, Jaina is unusual for its large number of clay figurines. It is interesting principally because of these remarkable pieces, one of which appears on the cover; they date from the Mesoamerican Classic Period and are found in the innumerable graves located throughout the island. Jaina is a small, mangrove-bordered island off the coast of Mexico, thirty miles north of Campeche, and separated from the mainland by a narrow channel. On pages 40 to 47, Dr. Luis Aveleyra A. de Anda of Mexico and Dr. Gordon Ekholm of New York discuss discoveries and theories surrounding the figures.

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Salvaging Egypt's past

By Henry G. Fischer

Rescued Treasures of Egypt. by Max-Pol Fouchet. *McGraw-Hill Book Co., $10.95; 269 pp., illus.* Abu Simbel, by William MacQuitty. *G.P. Putnam's Sons, $15.00; 192 pp., illus.* High Dam at Aswan, by Tom Little. *The John Day Co., $5.95; 242 pp., illus.*

The last vestiges of an entire segment of Nilotic life, both ancient and modern, are gradually being expunged as each annual flood raises the water blocked by the new Aswan Dam. By August, 1964, when the flood rose to exceptional heights, the Nubian population had already been evacuated; archeologists were facing their last chance to finish up work at all but a few unusually lofty sites such as Qasr Ibrim in Egypt, and other fortresses in the northern Sudan; and most of the temples had been transported to safety. The greatest monument of all, the temple of Ramses II at Abu Simbel, had hastily been given a two-year respite by the construction of a special cofferdam, so that it, and the smaller temple to the north of it, could be dissected and removed. Next summer's flood will top that barrier and virtually end all further efforts to salvage the past of a barren, but fascinating, terrain—the threshold between Egypt and the upper reaches of the Nile.

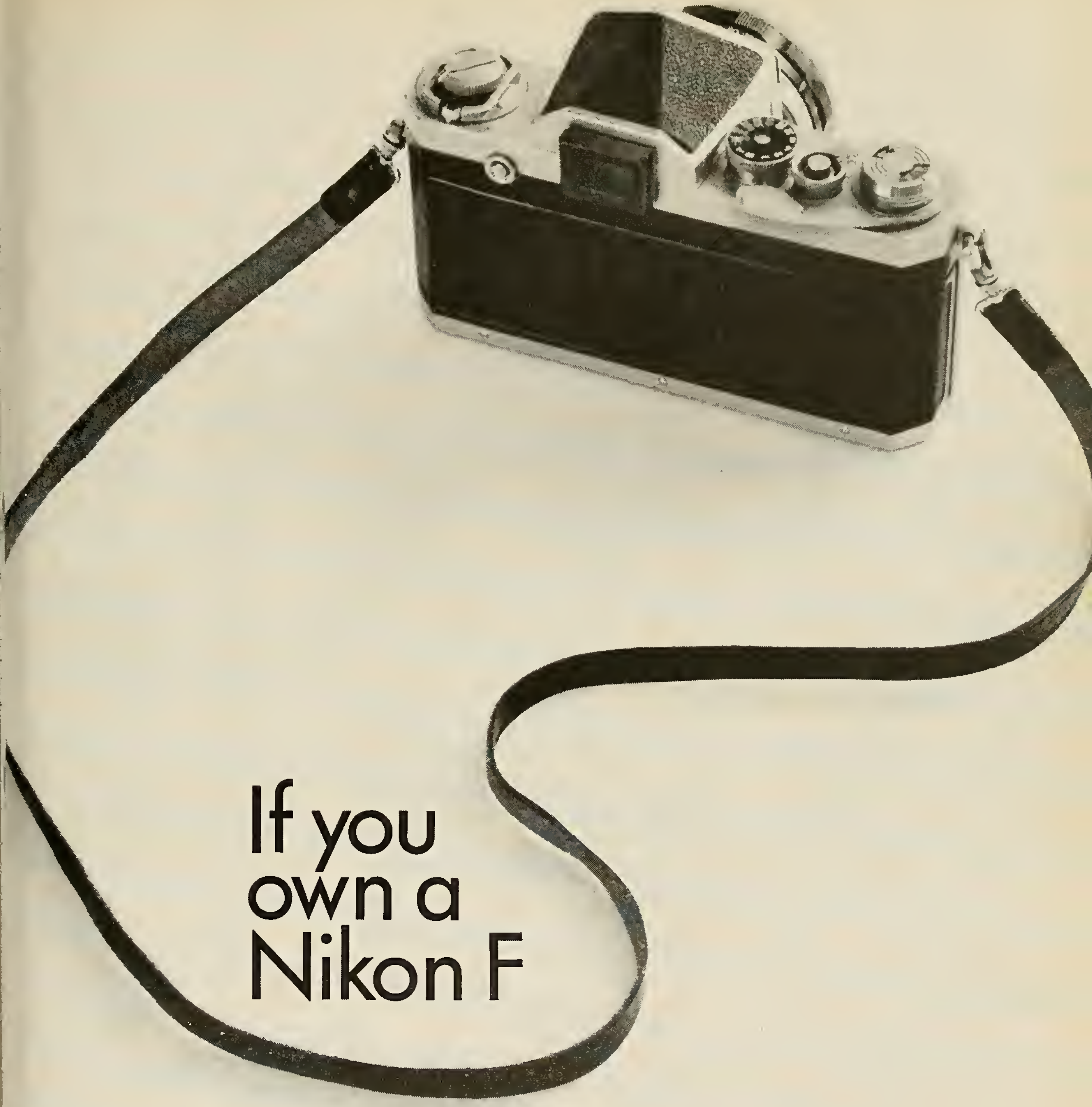
Max-Pol Fouchet's *Rescued Treasures of Egypt* presents the most comprehensive photographic survey of the Nubian temples that has yet been published, supplemented by a few pictures that round out the story of Ramses' temples at Abu Simbel by showing his statue in the museum at Turin, his funerary temple in western Thebes, and the tomb of his queen Nefertari. The quality of the illustrations is excellent, their selection is judicious, and their reproduction is good despite the use of offset printing.

Rather less can be said for the text. Although Mr. Fouchet is a former professor of art history, and has done a considerable amount of reading on the subject of Nubia and its exploration, he is evidently not completely at home in the field of Egyptian art and archeology. For this reason, and perhaps because of the exuberance of his style, he sometimes puts false emphasis on the facts, or mistakes the facts altogether. If, however, one allows for a few inaccuracies, and can weather rather gusty French rhetoric in overliteral translation, Mr. Fouchet is worth reading, and the relation of pictures to text is easy to follow.

William MacQuitty, a Belfast film producer who proposed the English plan for saving Abu Simbel *in situ* within a reservoir of filtered water, has produced a volume (*Abu Simbel*) that has little value apart from a two-page exposition of his scheme. His style of writing shows greater restraint than Mr. Fouchet's and the accuracy of his statements has been assured by Dr. I.E.S. Edwards of the British Museum. But the reader who expects to find a relatively detailed description of Abu Simbel will be disappointed to find that more than half the pictures, and a good deal more than half of the brief and drab text, are devoted to other subjects, ranging from the inevitable mummy to the kilowatt potential of the new dam. Few of the pictures do credit to the subjects, and the majority are poor in quality and content. The ill-conceived nature of this book is proclaimed by the cover design, a hastily executed drawing of Ramses' cartouche, enlarged in every wobbly detail.

As its title indicates, Tom Little's book, *High Dam at Aswan*, is principally concerned with the dam itself, rather than the problems it has left in its wake, although a fair share of attention (about one-third of the text) is given to these matters, with a good account of UNESCO's efforts to organize and finance archeological work and the salvage of monuments. The author is both candid and circumspect in dealing with the thorny political ramifications of his subject, and he discusses the potentialities of the new dam with a nice balance of enthusiasm and objectivity. Those who feel a personal loss in the permanent inundation of Nubia may find some consolation in his opening chapters, which leave one with the conviction that, whatever may be said for the new dam (and there is apparently much to be said for it), the project was inevitable.

All three books recognize the outstanding importance of Abu Simbel as the chief victim of what, one hopes, will be progress. As Mr. Little points out, the final response to UNESCO's appeal for funds to save it came so close to the total that, by the time the United States fulfilled its pledge of $12 million in August, 1964, "the Abu Simbel operation was considered by all concerned as home and dry." But there remains a deficit of $6.6 million, and at least half of this must be supplied in convertible currency for the purchase of equipment and materials outside of Egypt.



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Abu Simbel is indeed "home and dry" as far as its piecemeal removal is concerned, but there is still a risk that the shortage of funds may delay or suspend its reconstruction, and an even greater risk that economies will be imposed on the final phase of the operations—the restoration of the cliffs surrounding the temples. Since the esthetic impact of these monuments derives from an interrelation of architecture and setting, they will not have been preserved until that setting is restored with the utmost skill. An American Committee to Preserve Abu Simbel has been organized to seek further contributions for what is undoubtedly the most outstanding effort ever made to safeguard a part of man's artistic heritage.

Henry G. Fischer is Secretary-Treasurer of the American Committee to Preserve Abu Simbel and also Curator of Egyptian Art at the Metropolitan Museum of Art.

The Native Americans, by Robert F. Spencer. Jesse D. Jennings, et al. *Harper & Row, $10.90; 539 pp., illus.*

Although designed primarily as a textbook for colleges, *The Native Americans* is excellent for the general reader who is looking for an authoritative summary of North American Indian archeology and ethnology in a single volume. The book was written by nine authors, each writing a chapter (or chapters) on his specialties. This plan was adopted because the literature on American Indians has become so vast that few anthropologists are familiar with all of it. The result is a big book (some 400,000 words) that is filled with data. It is useful both as a general introduction and as a reference book.

The Native Americans begins with a chapter on archeology. Like the other chapters, it is full of information; yet it manages to highlight the principal developments of American Indian prehistory so that the reader never becomes bogged down in details. Next follows a chapter on linguistics. Language is a subject about which it is difficult to say much without becoming highly technical. The authors have kept this chapter brief, but they still manage to give some idea of the complexity and diversity of Indian languages. Most of the book is devoted to a survey of the historical tribes, organized by culture area. A final chapter gives a historical summary and a discussion of Indian prospects.

The book has a number of noteworthy features. Archeology is not slighted, as it often is in books that are primarily ethnological. The ethnology of northern Mexico and Mesoamerica is included, thereby wisely ignoring the distinction frequently made between Anglo-America and Latin America. Each chapter on a culture area contains a few short ethnographic descriptions of particular tribes. Areal surveys tend to focus on the distribution of culture traits, and it is well to be reminded that the individual Indian lived in a tribe with an integrated culture. The final chapter discusses the Indian policy of the United States government and the current legal status of Indians. Although these are topics of importance, they are usually omitted in books on Indian ethnology.

The weaknesses of the book are minor, and yet their total effect is to reduce its usefulness considerably. The index is inadequate, making it difficult to locate information. The "Guide to North American Indian Tribes" is of little value, as it is nothing but a list. At the very least, the culture area and linguistic family of each tribe might have been added. The authors should have standardized tribal names throughout their book; for example, the Saulteaux are given both as a separate tribe and as a part of the Ojibwa. A major fault is the poor quality of many of the illustrations. All are line drawings, but photographs would have been much better in many cases. Although the book has a large number of drawings, there is no list of figures. The book contains enough technical terms to make a glossary a useful addition.

The Native Americans is one of the two best general books on the American Indians (*Indians of North America* by H. Driver is the other), and will be a standard reference and text for many years. Anyone who reads it carefully will acquire a most respectable knowledge of American Indian ethnology and archeology.

Stanley A. Freed
The American Museum

Rhinos Belong to Everybody, by Bernhard Grzimek. *Hill and Wang, Inc., $12.50; 207 pp., illus.* The End of the Game, by Peter H. Beard. *The Viking Press, $12.95; 256 pp., illus.*

The book *Rhinos Belong to Everybody* is a collection of 128 outstanding photographs, of which 58 are in color. They have been well chosen and are superbly reproduced. The majority are of African game mammals, but birds, people, and scenery are also included. To add to the delight of this book, the author has provided a readable and enlightening text.

Dr. Grzimek, the director of the Frankfurt Zoo, is a widely respected conservationist. He has made numerous trips to Africa, and this book tells the story of his latest journey, in 1960-61, when he revisited some of the areas he had covered some ten years before—the eastern Congo, the Ngorongoro Crater, Serengeti National Park, and Tsavo Na-

tional Park. He found that great changes had taken place, but was pleased to learn that some of the new governments were trying to patrol and save the parks. However, the Ngorongoro Crater was being used by the Masai for pasturing their cattle, the rhinoceroses were being slaughtered for their horns, and the outlook was bleak for the other animals that used to roam the floor of the crater by the thousands.

Dr. Grzimek feels that many of the governments appreciate what the national parks mean to Africa, chiefly as tourist attractions, but to keep the parks running and to protect the animals from poachers takes more money than these governments can now afford. Unless financial aid is forthcoming, the animals are doomed.

The End of the Game is a brief history of Africa from the time of the early explorers to the present. As Mr. Beard says in his introduction, the book is "a memory of the past, a record of the present and an image of the future. It is concerned with the end of the game and the end of an era."

One of the chapters deals with game control: the deliberate slaughtering of animals to keep their populations from increasing. An advancing civilization may deem this necessary, but it does not make for enjoyable reading. Although Mr. Beard does not appear to be a professional conservationist, he is pessimistic about the future of the animals, and greatly laments the passing of the old Africa with its great animal wealth.

The 45 full-page illustrations, 12 in color, are hardly up to standard. Many of them depict dead game, perhaps to emphasize some of the text, but they certainly detract from the appearance of the book.

T. Donald Carter
The American Museum

The Appalachians, by Maurice Brooks. *Houghton Mifflin Co., $6.95; 346 pp., illus.*

The publication of *The Appalachians* by Maurice Brooks heralds the arrival of a new series entitled "The Naturalist's America" under the editorship of Roger Tory Peterson and John A. Livingston. If the first volume is a true harbinger, this will be a series that will be found on the bookshelves of every person with a love for wild America.

I have read this book as a westerner who knows the east mostly from books, but who will soon be emigrating to the eastern seaboard. As such, I find that Maurice Brooks has instilled in me a great desire to hike the Appalachian Trail, travel the Skyline Drive, learn to recognize the eastern birds, wildflowers, and trees. His writing provides a fitting introduction to a new world and new ad-

venture in the oldest mountains of the United States. The reader can hardly avoid an itch to roam the Great Smokies, wander through the Blue Ridge, climb Mount Mitchell and Mount Katahdin, and see the Gaspé and the Shickshocks.

As one who has grappled with a similar writing job, I admire the artistry with which Mr. Brooks breathes life into what otherwise could be a mere listing of strange plant and animal names, and makes you feel that you must see the creatures involved and come to know them as he does. Apart from being an excellent regional guide, this book is a pleasant introduction to ecology and natural history for the beginner and a good refresher course for the expert. The reader will not only learn to appreciate the eastern mountains and discover the fascinating complexity of their biota; he will also learn much about the "whys" of living things, the processes involved, and the interrelationships in wild nature and natural beauty.

RAYMOND DASMANN
The Conservation Foundation

THE ROCK PAINTINGS OF THE CHUMASH, by Campbell Grant. *University of California Press, $10.00; 163 pp., illus.*

FIGURES that the American Indians painted on rock surfaces (pictographs), or carved into them by incising or pecking (petroglyphs), compose one of the most frustrating categories of evidence with which anthropologists deal. In the past they yielded so little reliable cultural or chronological information that their study was largely neglected by students who, heaven knows, had little enough time or resources to get on with inquiries into the more fruitful classes of facts.

Since World War II there has been renewed interest in pictographs and petroglyphs. Interpretation is still difficult—in fact, usually impossible—but recording moves apace. Campbell Grant, artist and author working under the auspices of the Santa Barbara Museum of Natural History, is in the forefront of such studies on the West Coast, and *The Rock Paintings of the Chumash* is a product of his dedication to the subject.

Recording the figures, chiefly pictographs that the Chumash wrought on eighty-four sites scattered over 6,500 square miles of territory in the Santa Barbara region, was a grueling task. Explaining them was even harder. Grant discovered he had to go deeply into the ecology, culture, and history of the Chumash—a task that resulted in his writing the ethnological discussion that precedes, and by pagination exceeds, the presentation of his pictograph reproductions and their interpretation. This section of the book is a valuable contribution to knowledge about the tribe.

The figures are a superb group of thirty-two color plates representing both painted reproductions and color photographs, as well as numerous black-and-white pictures. There was considerable range of complexity, subject matter, and even eerieness in the figures Grant found. Some are abstract, some natural, some overlay others, and nearly all are brightly painted (NATURAL HISTORY, June-July, 1964). Some repeat, but nowhere are there repeated groups of elements in the sort of sequence patterns likely to lead to acceptable interpretation.

In the end, neither ethnology nor archeology helped much with the explanation. Grant falls back at last on the same generalities as have the rest of us engaged in such studies: the figures were probably magico-religious, designed to put man in harmony with the unseen forces that control the world.

This beautifully done book is a must for a student of pictographs and petroglyphs, and a useful and entertaining volume for anyone's library.

JAMES L. SWAUGER
Carnegie Museum

THE DISCOVERY OF NATURE, by Albert Bettex. *Simon and Schuster, $24.95; 380 pp., illus.*

ALBERT BETTEX' *The Discovery of Nature* discovers not only nature but also its discoverers through a magnificent series of historicoscientific illustrations. The illustrations are well reproduced (the book has been printed in Switzerland), but as important, they have been chosen with imagination and are of great diversity: a sepia drawing of Stonehenge by Turner; a Chinese Ming painting of man in communion with nature; a Fabris painting of William Hamilton beside erupting Vesuvius; Roesel von Rosenhof's illustrations of the activity of the ant lion; a fourth century B.C. clay tablet depicting fishes and shellfishes—these are only a few of the types of figures that accompany the expected woodcuts and engravings. Their variety defies exemplification in a short notice. The subjects covered include chemistry, physics, botany, zoology, anatomy, and astronomy; a brief concluding chapter, "The Natural Sciences," is somewhat philosophical.

What really distinguishes the book, however, is a text as imaginative and as excellent as the pictures. It presents an accurate and fascinating account of how man has discovered nature and what he has discovered about it, and it also describes how he has welded his discoveries into science. This book is enthusiastically recommended to scientists and teachers of science at all levels, and to students of science, lay or professional.

JANE OPPENHEIMER
Bryn Mawr College

FRACTION OF SUN'S HEAT CAN GENERATE TORNADOES

A Storm's Incalculable

by EDWIN KESSLER

The sun is the source of energy that causes weather and maintains conditions on earth suitable for life as we know it. Of the total solar output, the earth intercepts only about a two-billionth part, but this is enormous by comparison with man's uses. Just a fraction of this tiny fraction is changed to the energy of weather motions, yet the energy is still far greater than the total produced by all the works of man.

The solar energy that falls on a flat plate perpendicular to the sun's rays at our distance from the sun is about 2 calories per square centimeter per minute, or 1,800 calories per square foot per minute outside the earth's atmosphere: the latter amount is enough to turn 3 grams of water to steam each minute. One calorie is the heat required to raise the temperature of 1 gram—1/30 ounce—of water 1.8° F. On a dry day, about 20 per cent of the incoming solar energy may be reflected and absorbed in the atmosphere. Thus, one square mile of the United States' surface receives about 2,800,000 kilowatts, or 3,700,000 horsepower, during a dry, bright midday in summer. The solar energy falling on an area ten miles square is considerably more at midday than the total power generated by all the power plants in the United States. The heat received at the earth's surface during 24 hours is, typically, enough to heat the overlying atmosphere by about 5° F. This is an average. Ninety-nine per cent of the atmosphere is below 100,000 feet; 50 per cent of that is below 18,000 feet.

Most of this enormous amount of energy is radiated back to space, and most of the radiation is not changed to energy of motions. Instead, it maintains the temperatures on the earth near their average values. The temperatures of the earth's surface and atmosphere are constantly fluctuating about an average in response to the varying rates at which solar energy is

Twin tornadoes are seen cutting path through Kansas in dramatic picture.

Energy

eceived. Thus, the temperature rises uring the day and declines at night. it any moment in time, temperatures end toward the level at which a balnce can occur between inward and utward transfers of radiation and the ransfer of heat by mass transport, or urbulence. The amount of radiation mitted by the earth increases with its emperature; when day length ineases as the sun rises higher, radiaion income increases and exceeds the mount radiated to space by the earth nd its atmosphere. Then the temperaures of the earth's surface and atmoshere rise until the heat outgo is about qual to heat income. During a typical lay the temperature rise lags behind the sun, and a balance is usually achieved sometime after the noontime maximum of incoming solar radiation.

Some of the energy of the sun that is received on earth is converted to work before it is radiated back to space—a basic law of thermodynamics states that if work is to be done, there must be differences in temperature. A steam engine has a boiler, in which heat is added to make steam, and a condenser, in which heat is lost. If the condenser and the boiler were at the same temperature, it would be impossible to maintain the pressure difference that does the work. In the atmosphere, the temperature differences between equatorial and polar regions drive the global circulation.

When water is placed over a flame, the relatively high temperatures created at the base of the fluid cause vertical overturning, or boiling, which involves a transfer of some of the heat energy into energy of motion. A circulation in gases or liquids driven by temperature differences is said to undergo convection, and the atmosphere circulates convectively in both vertical and horizontal directions.

Thunderstorms and tornadoes represent vertical convection, and are most characteristic of the spring season when the temperature of the atmosphere near the ground is rising in response to increasing amounts of solar radiation. It is obvious that the atmosphere is nearly transparent to solar radiation, and the warmth of the illuminated earth's surface indicates that much solar radiation is absorbed by the ground. The base of the atmosphere is then heated by contact with the ground, and is somewhat analogous to the container of water over a flame. As the surface temperatures rise, vertical overturning is more likely, although several other factors, including the large-scale distributions of winds and temperatures. also influence the forms of local convection.

Two important features of the atmosphere are its compressibility and the existence of latent (hidden) heat in the presence of water vapor. Compressibility and latent heat are significant in producing the forms of convection characteristic of the atmosphere. The first factor is associated with a decrease of density and pressure in relation to height. A rising air parcel encounters lowering air pressure and expands. Thermodynamically, we can say that it works on its environment as it rises. The first law of thermodynamics expresses the conservation of energy, which may be manifested as work or heat. When a parcel of air rises, some of the heat content of the rising parcel is changed to work, and the parcel's temperature declines correspondingly. This must be considered in studies of atmospheric overturning.

The second factor, latent heat, implies that the actual heat content of an air parcel is not indicated by an ordinary thermometer, which measures only the sensible temperature. This, too, must be considered in connection with vertical motion. As rising air cools, its capacity for holding moisture decreases. After the air's vapor content exceeds its water-holding capacity, condensation accompanies rising motion, and the heat that is latent in the vapor is released. This partially compensates for the tendency of the temperature of an air parcel to fall as the air mass rises, in response to the work done on surrounding air.

When the atmosphere overturns, the temperature of a rising air parcel is higher, and its density, or weight per unit volume, is lower than its surroundings. As rising air becomes relatively warmer, it rises more rapidly, just as more buoyant objects shoot more rapidly to the surface of water.

With a sharp enough decline in air temperature as height increases, the temperature of a rising, moist air parcel is appreciably warmer than its surroundings. Large temperature differences between the rising air and its environment are associated with relatively efficient conversion of heat energy to energy of motions and, thus, with vigorous vertical convection, including thunderstorms and tornadoes.

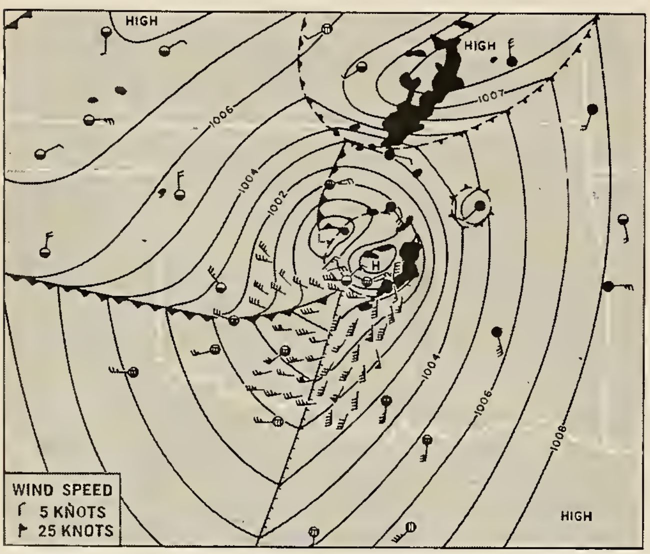
One remarkable aspect of our atmosphere is the way it arranges itself so that heat and moisture added far away contribute repeatedly to the occurrence of static instability at favored locales. This is especially evident in the case of midwestern thunderstorms.

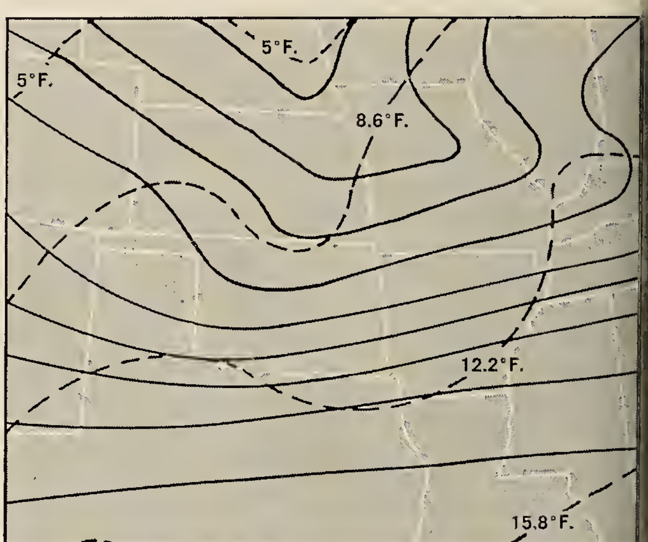
Thunderstorms and tornadoes form when moist spring air is drawn northward from the Gulf of Mexico. In the lower atmosphere, generally, the temperature decreases toward the north. This is associated with a veering of the wind with height, which can be explained in terms of the different densities of warm and cool air and the

Top of thunderhead formed during severe storm activity is about 45,000 feet high.

change of air pressure that occurs with altitude. In other words, the winds at intermediate and upper levels have a westerly component. This upper-level air from the west is often dry, perhaps because it has been lifted over the Rocky Mountains and has dropped rain on their western slopes.

Although the moist, low-level air blowing from the south is a reservoir of great amounts of latent heat, it is sensibly cool in spring because the Gulf is relatively cool then, and the air tends to stay at the earth's surface. This can be a stable situation until a large-scale weather disturbance causes widespread rising motion, which is also promoted by the movement of the Gulf air over rising terrain to the north. The upper air layers cool rapidly because they have little moisture and a correspondingly small reservoir of latent heat; the lower layers cool slowly as they rise, because so much latent heat is released as the moisture in those layers condenses. Since the upper layers cool faster than the lower, and the lower layers become relatively warmer, the whole depth of the atmosphere over the area of general ascent becomes more statically unstable. Finally, small-scale overturning can occur violently, caused by the great relative warmth produced in the lower strata. This convective overturning and accompanying precipitation is the severe thunderstorm phenomenon so



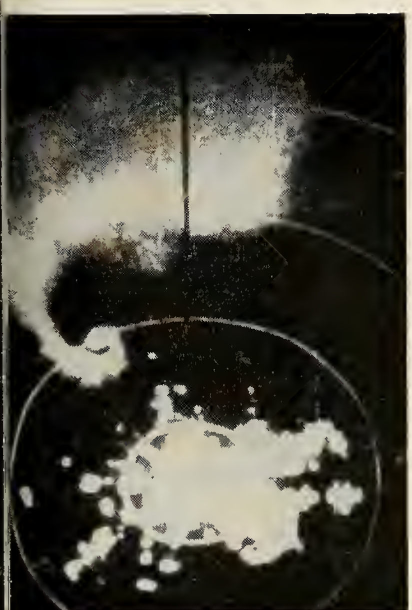


Surface map, *above*, shows direction and speed of wind. Solid lines on upper-level map, *right*, indicate heights of about 18,000 feet. Winds blow parallel to the height lines, an are at their greatest speed where lines are closest togethe

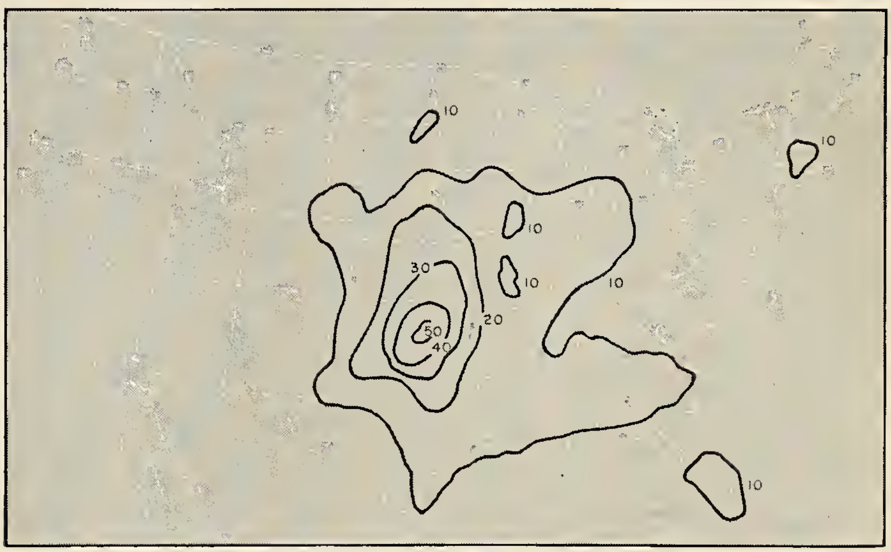
familiar in midwestern United States.

It is not well known at the present time why some violent thunderstorms are accompanied by tornadoes and others are not. It appears that tornadoes are promoted by certain configurations of the upper winds (jet stream) and perhaps by the flatness of our midwestern terrain. It also seems likely that the broad, westward upslope of the land west of the Mississippi, the presence of the Rocky Mountains, and the sensible warmth of the earth's land surface compared to that of the Gulf in early spring are all important in influencing the development of large-scale atmospheric features that favor the formation of tornadoes and violent thunderstorms.

The number of tornadoes in 1° latitude-longitude squares in the United States during the period 1953-62, inclusive, is illustrated below. A typical tornado may cover at one moment an area of about 1/100 square mile with winds averaging 100 mph. This is a conservative estimate, because the winds near a tornado core have never been accurately measured. The maximum winds are probably more than 300 mph. In our example, the mass (m) of air involved is about 2.5×10^{11} grams. The kinetic energy (energy of motion) is expressed as $\frac{1}{2}$ x mass x (velocity^2), which is about 3×10^{18} ergs. (An erg is the energy imparted over a distance of one centimeter by the force that accelerates a mass of one gram by one centimeter per second.) Since the energy of motion and heat are different forms of energy, the



Echo, associated with Meriden tornado, is seen in radarscope of Topeka, Kansas.



Numbers accompanying outlines, *above*, show tornado frequency from 1953-62.

amount can be written as 7×10^{10} calories. This is about 0.5 per cent of the solar energy that falls on a square mile of earth on a typical summer day, and 0.5 per cent of the heat of vaporization of one-half inch of rain over a square mile.

Of course, the tornado is a highly localized phenomenon, and much energy is represented in the weaker but possibly still destructive air motions associated with a thunderstorm over a very large area. Consider a possible situation in which 2 inches of rain falls over 100 square miles. The latent heat released is about 7×10^{15} calories, equal to about 350 atom bombs of the type used in World War II.

The second law of thermodynamics can be used to indicate how much of the latent heat released might be converted into energy of motion. (For this purpose we use the absolute temperature scale, where zero is —459° F.) The conversion process is more efficient as the differences of temperature are greater, as shown by the equation:

$$\text{Max. Efficiency} = 1 - \frac{\text{Av. cold temp.}}{\text{Av. warm temp.}}$$

The average temperature of the storm environment can be about 32° F., the melting point of ice, and the storm core about 5° warmer. Then the maximum efficiency of conversion of heat to mechanical energy is about 1 per cent. This is a small percentage, but the kinetic energy represented is enormous. If paid for at one cent per kilowatt-hour, it would cost nearly $1,000,000. The destructive power, of course, depends on how this energy is concentrated.

I have not mentioned the electrical phenomena accompanying storms. Most meteorologists believe that the energy of lightning is derived from the overturning of air, although intermediate processes of precipitation formation are probably of direct importance to the formation of electric fields. The average lightning stroke represents an energy of only about 10^9 calories, or a little more than 1,000 kilowatt-hours —a small fraction of the total energy of overturning.

Weather maps are used to predict and describe tornado movements. Tornadoes occur in association with thunderstorm radar echoes, seen as dark areas near the center of the map (*page 14*) that depicts air pressure and winds at the earth's surface. Notice that the thunderstorms occur along the outer edge of a small high-pressure area, and that near the storm boundary the winds shift dramatically. The shift line appears to separate rain-cooled air from warm air that has not yet been involved in the storms. This may be the source of the spinning motion needed to form a tornado in air that is caused to converge rapidly at low levels and then ascend.

The surface weather map also shows a cluster of weather reports from southwestern Oklahoma. These data are derived from stations maintained by the National Severe Storms Laboratory and co-operating observers and enable us to learn more precisely about weather configurations and the forces associated with tornadoes.

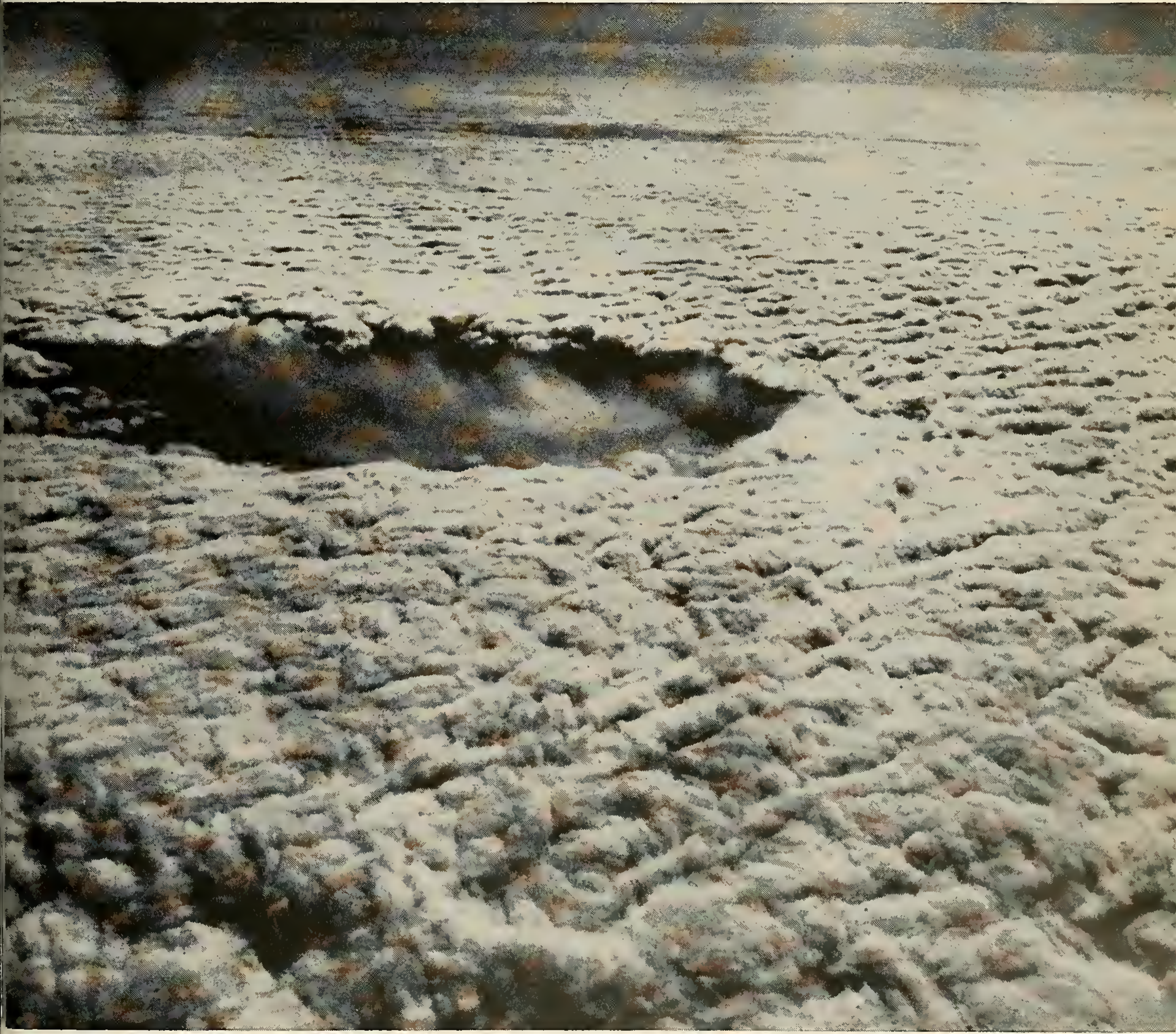
At heights where the air pressure is only about 500 mb., or one-half that at the earth's surface, the low-pressure area appears as a dip. or trough (*drawing, page 14*). Thus, lines of constant height where the pressure is 500 mb. are shown just one hour after the time shown on the surface map, which depicts earth surface conditions. The lower heights are toward the north; the solid lines in this figure are analogous to the lines of constant pressure on the surface map and are nearly parallel to the wind direction. Notice the difference of the wind directions at the surface and aloft, especially east of the center of the surface disturbance.

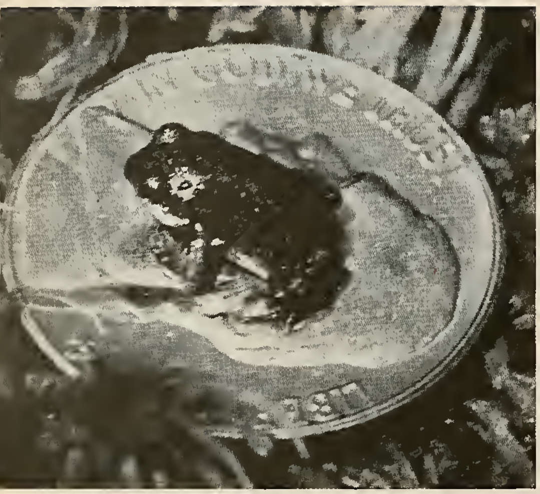
Radar has been most helpful in identifying and tracking tornadoes. and a tornado echo is shown on page 15. The echoes come from the precipitation-bearing parts of the storms. As you can imagine, radar data are also valuable for basic studies of tornado mechanisms. At the National Severe Storms Laboratory we are developing some new Doppler radars, with a hoped-for capability of measuring the speed of tornado winds.

We expect that efforts to learn more about severe storm mechanisms and means to identify them accurately will lead to improved weather forecasting and warning systems. The control of severe storm phenomena clearly indicates the control of energies far greater than those developed by man for his ordinary—or even his extraordinary—use. Man's ultimate ability to exercise an appreciable control of weather may, therefore, depend on knowledge of means for modifying the processes by which nature's sup- ply is utilized. An example of modifi- cation is illustrated below. The laten heat caused by fusion of condensec liquid water is released when snow is formed in supercooled clouds by the triggering action of dry ice or silve iodide. Thus, the relatively smal amount of energy involved in the re lease of seeding agents releases laten heat that can raise the air temperatur through a large volume by about 2° F The associated contribution to buoy ancy may stimulate the growth o some clouds and hasten the dissipatio of others. However, no studies hav yet determined if there are real pros pects for directing severe storms b this or other triggering processes usin energies on a scale accessible to mar

First complete view of world's weather was photographed by Tiros IX. Mosaic is made up of 450 individual photographs.

Over three miles wide, this hole in supercooled cloud deck, *below*, was created by using eleven pounds of CO_2 pellets.





Immature spadefoot is shown sitting on a nickel. The adult of any species seldom exceeds three inches in length.

Skin of spadefoot is thin and smooth, moist, but not slimy. Toad is dry-land animal except while courting or mating.

Unusual amphibian is equipped

It Could Be a "Froad";

By Aaron O. Wasserman

The spadefoot, *Scaphiopus*, is a biological marvel, seen only infrequently by the layman because of its nocturnal and burrowing habits. Few other amphibians can boast an ability to remain literally buried in seemingly powder-dry soil for such extended periods of time. In the Southwest, where upper layers of soil often become a cement-like mass, extended sieges of drought may imprison the spadefoot several feet below the surface for weeks or months at a stretch. Rainfall in these areas frequently results in flash floods and rain pools the size of ponds or small lakes. It is then that the spadefoot emerges on a temporary parole. In a few short hours it must feed to store up food reserves for the next "burial," and usually it breeds as well. Its young must complete development into tadpoles and transformation to young toads before the rain pool becomes a mudhole under the searing sun. While many amphibians average two or three months to complete this process, and some may take years. Couch's spadefoot of the Southwest has been observed speeding from fertilized egg to hopping toadlet in nine and a half days.

Scaphiopus, the sole representative in North America of the rather primitive family Pelobatidae, resembles the European spadefoot, *Pelobates*, after which the family of some eight genera is named. Other pelobatids are distributed in North Africa, southeastern Asia, the Philippines, and the Indonesian Archipelago. Four species (and several subspecies) of *Scaphiopus* occur in the United States.

Not only are "scaphs" unusual in habits and development; they are unique in appearance as well. When most people think of tailless amphibians, two categories come to mind: a frog, with a thin, smooth, generally slimy skin; or a toad, with thick, rough, warty skin. Frogs tend to be relatively aquatic, while toads do not. Spadefoot skin is thin and smooth, moist, but not slimy; spadefoots are strictly dry-land animals ex

with tubercles for burrowing

Maybe a "Trog"

cept while breeding. Properly, perhaps, they should not be referred to as either frogs or toads, although generally toadlike features prompt most people to call them spadefoot toads. "Froad" or "trog" have also been suggested, but only facetiously.

The easiest way for the uninitiated to recognize a spadefoot is by its pupil, which contracts to a catlike, vertical slit in bright light. This trait is found only in spadefoots and the tailed frogs of the Pacific Northwest. All other amphibians of the United States have pupils that are round or horizontally slit. The spadefoot's iris is a gold color with black or brown veins.

The eastern spadefoot may reach a maximum length of approximately two and a half inches from snout to rump. Couch's spadefoot is generally larger and may exceed three inches.

On the tarsal segment of the hind foot is a horny, black, cutting tubercle, which gives the spadefoot its common name. Shaped like a crescent or fingernail paring in some species, and somewhat like a lopsided fingernail in others, the spade grows from the inner surface of the foot, near the first (innermost) toe. The spade of the eastern spadefoot is approximately three-sixteenths of an inch long and crescent-shaped. Hammond's spadefoot and the central plains spadefoot have a wedge-shaped spade.

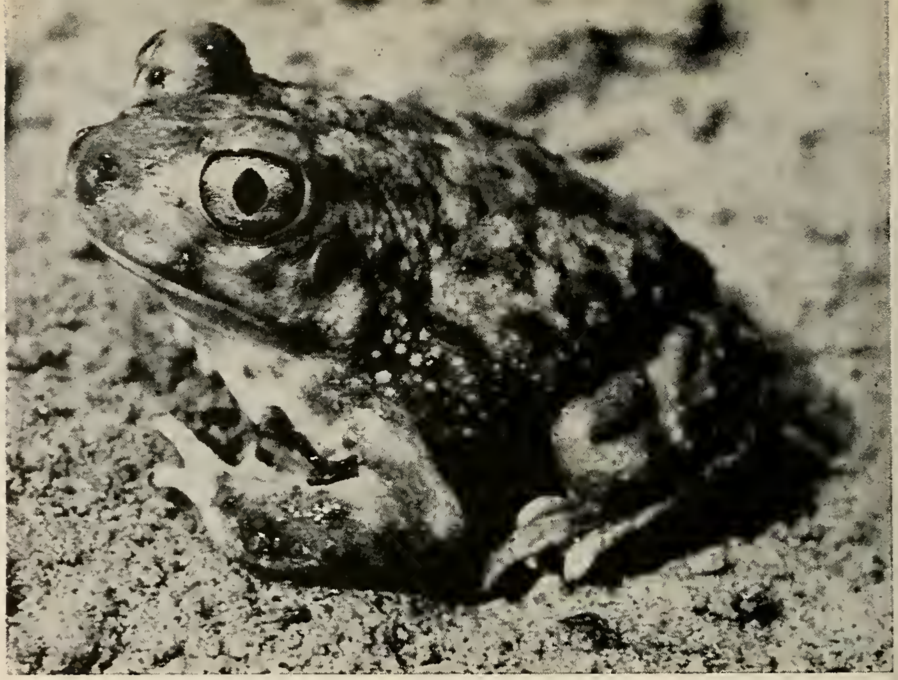
Similar spades are found in the common toad genus *Bufo*. A smooth, milky-white belly is characteristic of all scaphs, while greens, browns, and grays are dorsal colors, depending on species and sex.

When handled, spadefoots will often emit through numerous glands a sticky secretion with a musty or garlicky odor. Not a few people have found themselves violently allergic to this secretion. Sneezing, coughing, watery eyes, and even skin rashes have frequently been reported by herpetologists. Woe betide the unsuspecting soul who rubs his eyes after handling one of the animals. The reaction is frequently an excruciating, burning sensation, and the eyelids may actually swell shut. This powerful skin venom, which has apparently never been analyzed, has given potential predators most unpleasant experiences, and many animals will have nothing to do with *Scaphiopus* after the first taste.

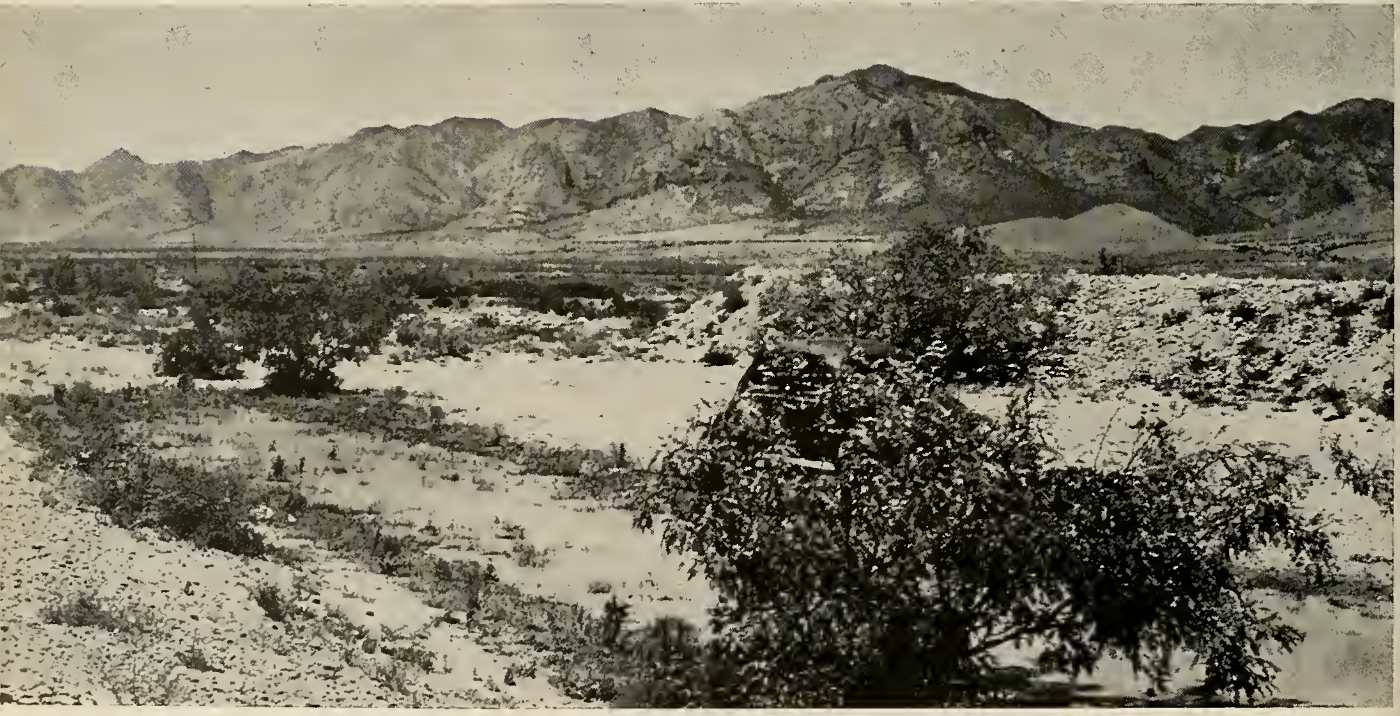
However, spadefoots are not free from predators. Hognose snakes will down them with no apparent ill effects. They have been found in the stomachs of the checkered and black-necked garter snakes. But probably the greatest toll is taken in the larval stage by such predators as water beetles, snakes, and birds. Grackles have been observed feasting on spadefoot tadpoles stranded in drying rain pools. What is not generally appreciated is that occasionally, especially in the Southwest, spadefoot tadpoles are their own worst enemies, for they have been observed to turn on their neighbors (perhaps a brother or sister) and engage in cannibalism. But second thoughts suggest that in the face of food scarcity, natural selection has taken the course of insuring that a few survivors are better than none.

Early accounts of these animals gave rise to the belief that they are rare, especially in the northeast. Thus, in 1886 Col. Nicholas Pike wrote that "even the most knowing, in nine cases out of ten, will only find a Spadefoot by accident." And Edward D. Cope stated in 1889 that "This species [Holbrook's spadefoot], though so widely distributed is seldom seen." Probably they have always been as abundant as other amphibians—perhaps more so—but in view of their secretive and nocturnal disposition, it is understandable that they would earn a reputation for rarity. Yet, I have encountered Hurter's spadefoots on east Texas roads in such large numbers that they actually

Pupil of *Scaphiopus* eye contracts to a vertical slit; most toads in the United States have round or horizontal pupils.



Typical rain pools, such as this one in a valley near Portal, Arizona, are the breeding places of the spadefoot.



seemed to be carpeting the pavement.

Although spadefoot activity usually increases during or after rains, individuals in milder regions of the country will often emerge to forage at night, even when there has been no appreciable precipitation for days or weeks. A voracious feeder, the spadefoot will take almost any animal it can seize, overpower, and swallow. Probably the item most frequently eaten by the adults is the beetle. Other insects taken include moths, flies, bugs, ants, wasps, grasshoppers, and crickets. Spiders probably make up a good portion of their diet. Heavy rains usually drive to the surface such burrowers as earthworms and beetle grubs, and these soft-bodied delicacies are readily consumed by spadefoots. Greater gluttons among amphibians would be hard to find; they often gorge themselves to the bursting point. After feasting on June beetles, Couch's spadefoot becomes a "butterball," so weighted down it can barely hop.

Southwestern and Florida spadefoots are encountered with far greater frequency than are their northeastern cousins. The latter probably rely on fewer, but more productive, feeding nights, which enable them to build up stored food reserves in fat bodies within the body cavity. These must sustain them through the cold winter months until the next feeding. In the northern region of their distribution, the eastern spadefoot will feed on most warm, moist nights from spring to the first cold snap of autumn, when insects disappear for the winter. They will then bury themselves, not to emerge for about five or six months.

At the end of its evening of feeding the spadefoot will settle itself in a likely spot, and with a few wriggling or rocking movements of its hind feet, it uses the spade to dig itself backward into the ground. In minutes it is completely buried. Last to disappear are the jewel-like, bulging eyes, which remain open until the last possible second. As they are touched by the first

soil particles, they shut tightly and sink into their bony orbits. Digging may continue, slowly submerging the animal in a spiral that descends vertically or somewhat diagonally for several inches or up to ten or twelve feet.

All amphibians are dependent on water or moisture for survival, and the spadefoot is no exception. It will be recognized that the habit of digging enables the spadefoot to follow its moisture downward in geographic areas that are forbidding to most amphibians. The depth of the desert spadefoot's descent is thus directly related to the depth of the uppermost soil moisture. In many areas of the Southwest, where dry stretches may bake the soil crust into a layer of extreme hardness, the spadefoot takes advantage of the burrows of other animals, such as kangaroo and pack rats, and occasionally turns up in the soft, moist soil of a gopher mound.

ACTUAL holes or burrows of a permanent or semipermanent nature are not formed by most spadefoot species. This is because the soil crumbles and collapses about the animal as it digs itself deeper. Only in the deciduous forests of the southeast does the eastern spadefoot form a permanent or semipermanent burrow with a mouth opening. Elsewhere, it is virtually impossible to detect or recognize the scant surface mounds of a fresh spadefoot excavation. Night after night these animals occupy the same burrow, often feeding from the entrance-way without venturing out. A headlight will hypnotize them, and the observer can usually spot them by the dull, pearly-red glow of their eyes.

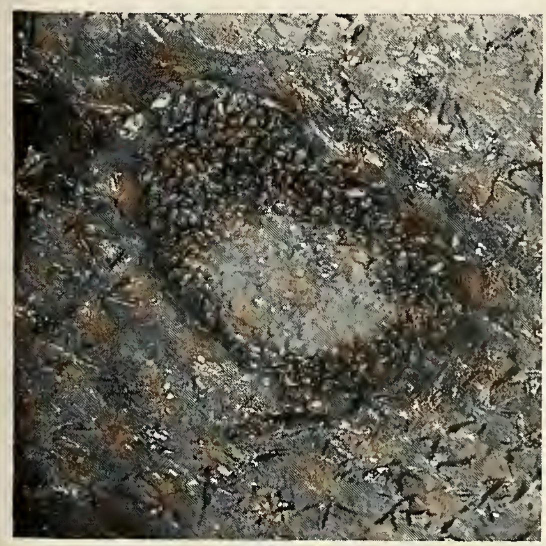
As the scaph stops its digging, breathing movements of the throat and flanks become less numerous and somewhat irregular until they cease altogether. Internal activity slows to a bare minimum and respiration occurs entirely through the skin. Water is stored in the urinary bladder and body cavity; when available in the soil, it is absorbed through a small patch of translucent skin in the venter region.

Mating behavior and breeding are invariably initiated by torrential rains, provided temperatures are in the fifties or higher. Southeastern spadefoots often breed in late summer or early fall during and after hurricanes. In the Southwest, breeding aggregations appear on warm nights during or immediately following heavy rains, usually between March and September. Brief showers of a half-inch or less will bring desert spadefoots to the surface to feed, but rarely to breed, although a few males may be carried away in a fever of excitement and begin to call. It is only after a "gully washer" of better than one inch, in which sizable rain pools are formed, that breeding activity is stimulated. Usually, the first to arrive at the pools are males, distinguished from females by the black excrescence on the inner surface of thumb and forefinger, and the bright greenish or yellowish suffusions over the solid back coloration.

Beginning a squawking or "yeowping" call that sounds somewhat duck- or crowlike, first-arriving males attract more males, until the chorus builds steadily to a droning roar. The sound of a full-blown spadefoot chorus is weird, and may carry for distances up to a mile or more. As each male calls, his throat inflates to an enormous white balloon. Typically, calling individuals swim or float, but they may also call while sitting in shallow water.

GRADUALLY, females are attracted to the chorus, and as they arrive each moves toward the nearest individual male call. Hopping or swimming for short bursts, the female stops —to take her bearings, as it were—then continues on a corrected course. Generally, she moves in zigzag fashion rather than in a straight line. When she has reached the particular male whose call attracted her, she will nudge him on the snout or side of the body. Until this physical contact is made, the female may just as well be invisible for all the notice taken by the male. But at the instant he is touched, he reacts with frantic intensity. He immediately stops calling and attempts to hug her. In the final mating position, the male's forelegs are locked with *rigor mortis* tenacity around the female's pelvic region, and his chin presses against the female's back. In this entire mating procedure it is interesting to note that the male remains relatively fixed in position, while the female makes the selection.

Of course, this is usual among frogs and toads. Male spadefoots are indiscriminate when attempting to pick a mate (a trait they share with most other amphibians). They are frequently observed attempting to clasp females of other amphibian species breeding in the same pool, or they may attempt to clasp a clod of earth or



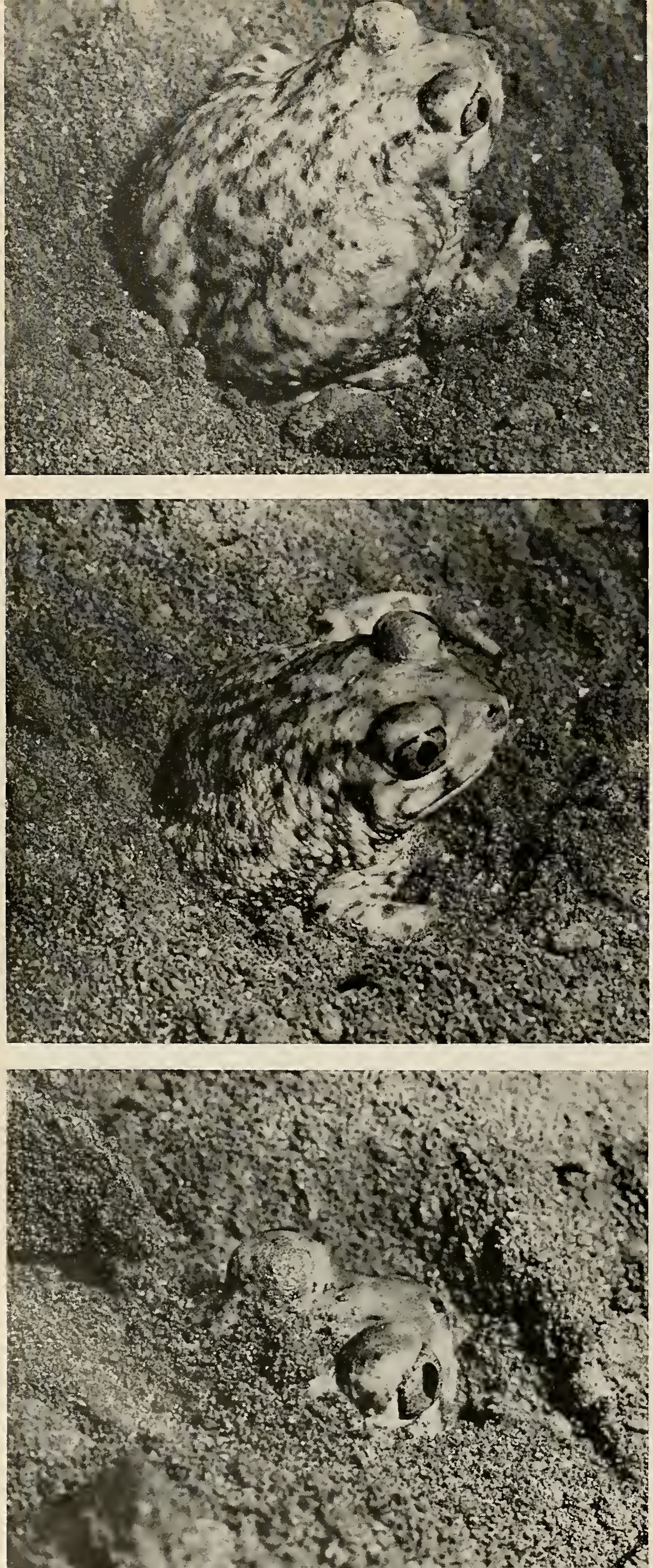
TRACKS around hole, *above*, are of predaceous birds. Ponds begin to shrink rapidly in sun, leaving tadpoles stranded.

All animals that have not metamorphosed are trapped in the drying mud; only a sudden rain will enable them to survive.

manure, a twig, or, as happens occasionally, another male spadefoot. This latter eventuality is rectified when the victim emits a warning or complaining note, while languidly stretching his hind legs. This always has the desired effect, and the aggressive male desists.

The intensity of the chorus abates gradually as the couples pair: eventually, the silence is punctuated only by the occasional bleat of a lone male. For a short time the clasping pairs float quietly on the surface, diving if danger threatens. When the female is ready to lay her eggs, she moves to shallow water. Passing a twig or stalk of vegetation between her hind legs, she produces a clustered mass of eggs, which are fertilized in the water as they pass the cloacal region of the male. The eggs adhere to the vegetation, thus remaining supported close to the surface, where they are assured an adequate oxygen supply, and where they will not be buried in the mud. Moments later, a membrane surrounding each egg swells by water absorption, forming a protective capsule of clear jelly around it. The eastern spadefoot is capable of producing between one thousand and twenty-five hundred eggs. Although more than one breeding has been recorded for a spadefoot population in a year, it is still to be determined whether an individual is capable of breeding more than once a year. Pairs leave the rain pool and separate after egg laying is completed. By dawn it is difficult to find a scaph.

Depending on such factors as amount of shading, cloud cover, and air tem-



Captive specimen of *Scaphiopus couchi*, *left*, is shown burrowing down backward into soft soil. Horny black spades on animal's hind feet, *above*, are used in digging, and give toad its common name.

perature, the shallow water of the rain pool may become very warm during the day. The higher the temperature the more the rate of development and growth of the embryo are accelerated. Couch's spadefoot of the Southwest often develops in exposed rain pools in which the water may be almost hot to the touch. In these, egg cleavage and development take place, and eventually a black larva is produced. It is some 6 or 7 mm. in length, and hatches from its jelly capsule about 30 hours following fertilization. Feeding on vegetation or whatever organic material is available, the tadpole becomes a bundle of activity that will only cease with its death or transformation.

It is ironic that heat—the factor that speeds its growth and development—also rapidly shrinks the aquatic world of the spadefoot tadpole. On several occasions I have visited rain pools reduced to puddle proportions, and have found seething masses of doomed tadpoles. The more successful ones may occasionally be seen emerging on all fours, tripping with each hop on their undiminished tails.

Upon successful emerging, metamorphic changes are completed rapidly, and within a day or two the young will resume feeding. Voraciously, they will consume such small insects as ants or beetles. At first they depend on finding tiny holes in the ground or in the shade of plants, but in a few days digging activity increases, and soon they are able to dig as successfully as their parents. Growth proceeds rapidly in the young spadefoot, and an increase to half or two-thirds of adult size in two or three months is not unusual. By the first heavy rains of the following year the young scaph may be ready to breed.

Spadefoot is a voracious eater; here one in a terrarium tackles a meal worm.

Polarized Beauty

MICA FLAKES REVEAL INNER FORMS

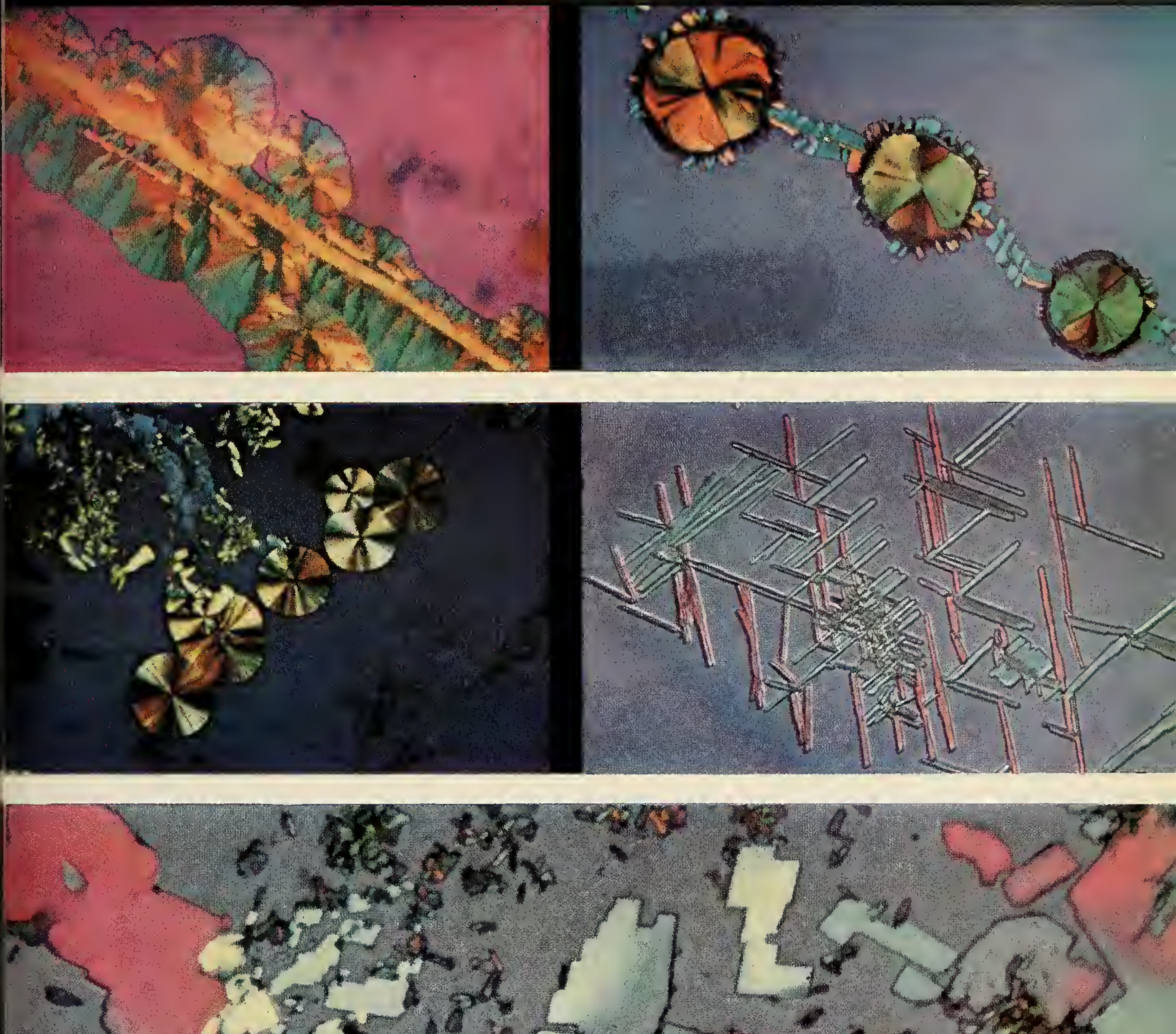
by WINTON PATNODE

Microscopists have long delighted in the kaleidoscopic appearance of diverse specimens rotated on the stage of a polarizing microscope. This type of microscope illuminates an object with polarized light—in which the vibrations of individual rays occur in a single plane—and permits observation through a polarizing film that may be rotated to block or transmit the illumination. Wave plates may also be inserted in the optical path to produce color by retardation and wave interference.

The pictures on the facing page are photomicrographs of tiny inclusions of various minerals found in mica. Their shapes were fixed by natural geologic processes deep in the earth, and their colors produced by careful alterations of the white light with which they were illuminated for photography. To a petrographer or mineralogist accustomed to using the polarizing microscope, the colors and forms convey information about the atomic structure of the crystals. To the layman they are fascinating, baffling, and sometimes disturbing phenomena—as if nature had taken up abstract art.

Such spectacles are no longer limited to professionals or those fortunate amateurs who can use expensive precision instruments. Excellent simple microscopes, polarizers, and wave plates are now available at low cost from dealers in laboratory and school supplies. Full instructions for producing and using polarized light may be found in books ranging from paperback handbooks to elementary and advanced textbooks. Seeing some of the hidden secrets of nature by polarized light is not only a satisfying intellectual pursuit but an esthetic experience. If not a wedding, it is at least a dalliance of science with the visual arts.

Mica is a particularly rewarding mineral on which to begin to explore polarization and light retardation phenomena. It is a readily available substance that can be stored indefinitely, and it is rich in a variety of crystalline inclusions. The transparent layers are quickly and easily separated to flat, rigid flakes of appropriate thickness for examination. No further preparation is necessary, and if so desired, hundreds of specimens can be examined and sorted in a matter of a few hours.



Evolution of the Web

Spider silk may first have been used only as covering for eggs

By B. J. Kaston

When you have seen a spider web, or brushed against one acciden- ally, have you ever wondered how the henomenon of silk use in spiders de- eloped? Of course, we do not know he entire story, but from the studies arried on by many observers, some arts of the tale can be seen to fit into pattern. For example, some spider- ings build snares that differ from hose they construct as adults, and be- ause the webs of these youngsters are ess specialized, they more clearly how resemblances to their ancestors' vebs. Here is one clue to our recon- truction of the story of web evolution.

Although only some spiders are web uilders, all produce silk. Chemically, ilk is a polymerized scleroprotein, and hat of spiders varies somewhat in its hysical properties according to which f several glands produce it. These lands all lie in the abdomen, and the ilk is emitted through ducts that dis- harge onto small appendages known s spinnerets, located at or near the osterior end of the abdomen, just in ront of the anus. Most spiders have hree pairs of spinnerets, provided vith many small spinning spools and pigots of several kinds and sizes; the ilk issues through their openings.

Spider silk is of two general types –sticky and non-sticky. The non-viscid s presumably the more primitive; it s made by all spiders and forms the tructural foundations of the webs. Viscid silk is of two types, depending upon whether the maker belongs to the Ecribellates or Cribellates—the two najor groups of higher spiders. In the Ecribellates, the viscid silk appears as ticky globules along the fiber, but in he Cribellates it is flocculent.

Cribellate spiders have special silk glands, with ducts opening through numerous fine pores onto the cribel- um, a sievelike plate lying just in front of the spinnerets. The cribellate spiders also have, along the dorsal surface of the metatarsal (the penultimate) segment of the hind legs, a single or double row of curved bristles, which compose the calamistrum. This is used to comb out the silk that issues from the cribellum, thus forming the flocculent threads. Ecribellate spiders lack the calamistrum (as well as the cribellum, of course), and their viscid silk is deposited as microscopic globules on dry threads (Natural History, June-July, 1965).

Two theories have been proposed to account for the evolution of silk. Since spinning arachnids other than spiders (the whip scorpions, false scorpions, and mites) have silk glands emptying at the mouth region, it has been suggested that spiders originally discharged their silk in similar fashion. The "spitting spider," *Scytodes*, still retains this trait, flinging a gummy material from its chelicerae. This is in addition to the more usual spinning apparatus that is used in producing the egg sac silk. Besides ordinary silk, the trap-door spiders use material from their mouths to cement particles of earth together to build their burrows.

According to a second point of view, silk was originally excretory material deposited behind as the spider ran about, and in some way this became the characteristic drag line that is trailed after the spider. When one considers the close proximity of the spinnerets to the anus and the way in which some, like the ground spider *Zelotes*, use excrement, in addition to silk, to fashion egg sacs, this theory seems plausible enough.

Spiders use their silk in many ways other than for web building. One such use—for covering eggs—suggests something about the evolution of the web. All spiders, as far as is known, cover their eggs with silk, and because mites, whip scorpions, and false scorpions also cover their eggs in this manner, one line of thought suggests that spiders first used silk to produce an egg sac, and that the web itself later evolved from a mass of threads distributed around the sac. While the spider hid with its egg sac in a crevice or hole, the silken drag line, which was emitted as she moved about, formed a lining for the shelter, and this eventually became tubular in shape.

Some spiders still build only this little tube, in which they hide, while others, in addition, have constructed one or more flaps, or doors, from which they can emerge to seize insects that touch or pass the flaps closely. There is a very primitive spider, *Liphistius*, that provides us with evolutionary evidence of other spiders. Its tubular, subterranean snare, from which we can trace the cribellate and ecribellate webs, shows us how the next step has been reached. In addition to a thin flap, or trap door, at the top, and a smaller flap at the opposite end to serve as an emergency exit, seven long threads extend from the rim of the upper aperture. Together these resemble radial threads of an orb web.

The further development of webs may be shown with *Liphistius* at the base and Cribellates and Ecribellates radiating from it (*pages 30-31*). Web evolution in these two groups has progressed along similar, but independent, lines—a phenomenon often referred to as convergence.

In general, the more primitive spiders live in, on, or near the ground, while the most highly developed web, the cartwheel-shaped orb, is aerial. Thus it is supposed that in the history of web building, ground types appeared first and were later followed by those constructed in space. The first webs made by spiders were of nonviscid silk, and the spider became aware of the presence of an insect when it hit the web and produced a vibration. When viscid silk was later added, the web also functioned in trapping the prey.

The sequence in which an orb web is spun has often furnished the observer with information that has been used in setting up the still-hypothetical

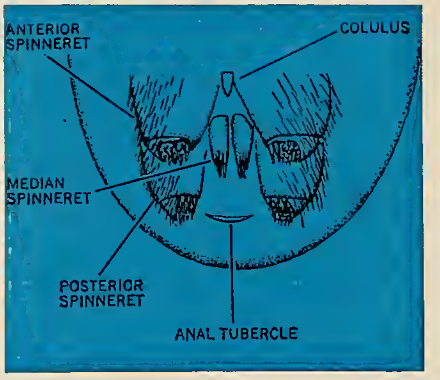
Garden spider, *Argiope aurantia*, is usually in center of orb web's snare.

tree of web evolution. The account that follows is based upon what is done by a mature female, since adult males often spin no webs and may even live out their relatively short lives on the web of a female.

The spider first ties together the objects between which the web is to be spun. This nearly always involves use of air currents to carry the thread. The spider tests the line emitted into the wind to determine when it has stuck. It then pulls this bridge line taut and fastens it. The spider crawls across the line, paying out a heavier thread that will serve as the bridge line. It then spins a frame consisting of foundation lines, which, together with the bridge thread, determine the plane of the web. The next step is to put in the radii, and in order that they may sustain equally the stretching of the web, they are connected by means of a few complete turns, or laps, of a spiral thread spun just outside the hub. This area is called the attachment zone. Once the hub and attachment zone are completed, the spider spins a spiral thread, starting at the end of the attachment zone spiral and continuing to the periphery, with turns as far apart as the animal can stretch. The scaffold spiral is temporary, and its function is to hold the radii in place during subsequent operations.

Now is begun the construction of the actual snaring spiral of viscid thread. This is always spun from periphery to center, but stops some distance short of the attachment zone, leaving an area called the free zone. The original scaffold spiral is cut away, turn by turn, as the viscid spiral approaches it. Once the catching spiral is finished, the spider has only to make a change in the hub. Some bite out the threads from the center, so that the hub becomes an open one. Others cover the hub with a dense sheet of silk. Some insert a band of silk above, or both above and below, the center. This "decoration," usually called the stabilimentum, may be straight, zigzag, or, in some cases, circular.

Although we began the account of the web's evolution with *Liphistius*, we must remember that the early arachnid from which spiders arose probably possessed no silk apparatus at all, but depended upon speed and agility in hunting and capturing its prey. Presumably, there then appeared those that used silk only to cover their eggs,



and representatives of this type can be found today. Some mothers even carry the newly hatched spiderlings on their backs as they run about. But there were those that hid with their egg sacs in a crevice, which eventually they lined with silk. This was followed by the elaboration of a door with fibers radiating from it. This entire bit of history can be seen in one group—the lycosids—which will be discussed in conjunction with the Ecribellates.

Let us first consider the cribellate line. We must conjecture that the earliest of these probably spun only some sort of tube. In the European *Eresus*, this tube is partly underground and partly over the surface, with a small sheet extending to one side. A larger sheet is constructed by the members of the family Psechridae. In the widely distributed *Amaurobius*, the tube is poorly defined, and there is a mass of threads extending in all directions from the lip. In *Filistata*, of warm climates, the tube is better defined, and the arrangement of threads extending from its mouth suggests the regular placement of radii in an orb. The situation is somewhat similar to that seen in the web of *Liphistius*, but the door to the tube is lacking.

In addition to the tubular portion, the Old World *Stegodyphus* has lines of silk arranged to resemble a sector of an orb, and these lines are irregularly banded with cribellar frets. *Sybota*, of Europe, proceeds further: the tube has disappeared, and the web, although no longer on the ground, is not completely in space, for the hub of the orb is always attached to a supporting twig or stalk. This would seem to be an intermediate condition between *Filistata*, whose web is entirely against a solid surface, and *Uloborus*, whose web is out in space. Another peculiarity of the web in *Sybota* is that no viscid spiral is spun; instead, the scaffold spiral remains, and the cribella silk is fastened to frame threads an radii. *Uloborus* produces a full orb with the sticky cribellar silk on th catching spiral, and with a stabilimentum. Yet only a scaffold spiral is foun in the web it spins as a young spider thus indicating a link with *Sybota* Here, nicely displayed, is one of th evolutionary clues.

The phenomenon of reduction i again encountered in the webs o *Hyptiotes* and *Miagrammopes*. We recall that in *Stegodyphus* the web included a tubular portion and a portio looking much like a sector of an orb If we lift this sector away from th tube and suspend it in space betwee twigs, we will have something resembling the web of *Hyptiotes*, the common, triangle-web spider of the woodlands. The web of the latter consist only of a triangular sector compose of four radii, which converge at th apex to form a single thread that i fastened to a nearby twig. To captur her prey, the spider, having fastene herself to the twig with a drag line holds taut the single thread attache to the four radii and releases the tension with a spring when an insec strikes the web. In the tropical stick spider, *Miagrammopes*, all that remains of *Hyptiotes*' sector is a singl thread about a meter long. For somewhat less than half its length, th central part is covered with cribella silk. This single line likewise function as a spring trap in exactly the sam way as that of its presumed evolutionary predecessor, *Hyptiotes*. The spide releases the tension when some insec alights on the thread and thus entangles the prey.

The last group of Cribellates to b discussed belongs to the family Dinopidae. These uncommon spiders construct a rectangle or trapezoid of dr silk, across which are spun a numbe of bands of cribellar silk. The spide holds the resulting snare, 10–20 b 15–25 mm. (or slightly larger), wit its front legs. When an insect approaches, the spider moves its fron legs apart, thus expanding the elasti snare to between 5 and 10 times it original size, and may even hurl th net over its victim. One can only conjecture as to the origin of this device

Since the Ecribellates are more numerous and variable than th Cribellates, the account of web evolution in this group will be more lengthy.

Here, too, we go back to *Liphistius* with its burrow. Many other spiders live all their lives in such burrows, with or without door flaps, and many either live this way while carrying their eggs, or place the eggs in such silk-lined holes. Some go a step further, extending the seven radiating threads into a sheet around the mouth of the burrow.

Present-day members of the wolf spider family, Lycosidae, show all the stages. For example, *Pardosa* is a hunter, and even at the time of impending motherhood roams the field stalking her prey with her egg sac attached to her spinnerets. Upon emergence from the sac, her children make their home on her back, where one may see them clustered like a bunch of grapes. Several of the *Lycosa* species make use of a silk-lined burrow, but only at the time of egg laying. Species of *Geolycosa*, on the other hand, spend all their lives in such burrows. It has been reported that some wolf spiders, such as *Lycosa aspersa*, even build doors for the burrows. *Pirata* builds a tubular nest among moss plants over water. Finally, *Hippasa* spins a sheet of silk around the entrance of the burrow.

The best-known of the tunnel builders that fashion doors are the trapdoor spiders, members of the family Ctenizidae. Some of these make thin "wafer" doors at the top (again like *Liphistius*), often with another such door at the entrance to a side chamber below. Later, the doors were strengthened so they were thick and fitted like a cork; they usually are held shut with surprising strength.

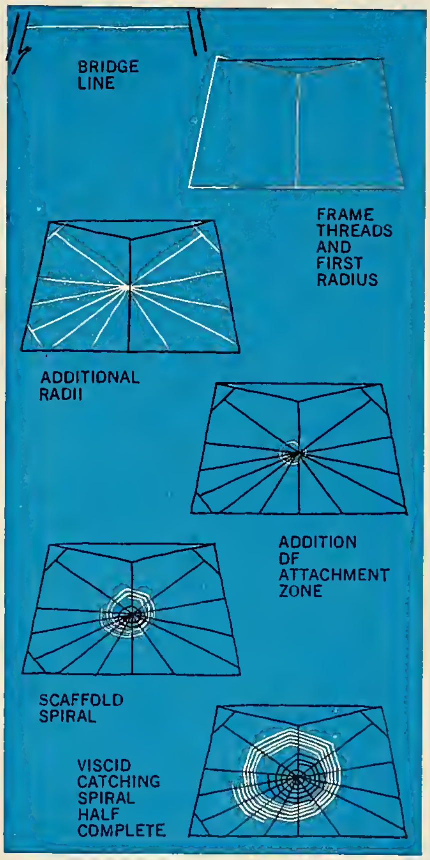
Another line of descent led to the typical tarantulas (Theraphosidae), many of which have temporary or permanent, silk-lined, shallow burrows in the ground. A few have become arboreal, while members of the closely related, tropical Dipluridae construct sheet webs over the ground, with one side fashioned into a funnel under a rock or in a crevice.

Paralleling the evolution of the theraphosids, ctenizids, and diplurids is that of the group of so-called atypical tarantulas. These display an even closer structural relationship to *Liphistius*. Some, such as *Hexura*, of our Pacific Coast states, run over the surface of their sheet webs. Others include the "folding door tarantulas," whose burrows are closed with a door composed of semicircular halves. And in this group we have the purse web spider, *Atypus*, whose web is a combination of a subterranean and a surface portion. First, the spider constructs a small horizontal cell—much like that of a jumping spider—on top of the ground, and from this it extends the tube downward. It has been suggested that the whole merely represents an elaboration of the ancestral cocoon.

Returning to *Liphistius*, we recall that a number of threads radiate from the lip of the burrow. Some of the more primitive spiders construct, in a crevice of rock aboveground, a silken tube with a similar arrangement of threads radiating from the mouth, although there is no door. Gradually, by the addition of many more radial threads, a kind of funnel was perfected around the entrance of the tube. Thus we have the kind of snare found in *Coelotes* today. The extension of the lower side of this funnel into a sheet gives us the typical agelenid web.

An added refinement to the funnel webs of many agelenids is the network of irregular threads above the sheet. This "stopping maze" catches flying insects, causing them to fall on the sheet, where the spider seizes them.

Let us now consider the ancestral spider that hunted on shrubs and herbage, and hung its cocoon among vegetation while remaining on guard. It seems reasonable to suppose that haphazard strands crossed one another at all angles, but radiated outward from the vicinity of the egg sac. Little by little, as the spider ran about trailing its drag line, additional threads were added around the egg sac so that a simple meshwork web was formed, much like that of long-legged *Pholcus*, and some theridiids of today. A continuation of this running about could give rise to the formation of a rough platform or sheet. In time, some of the spiders came to depend on the added protection of cracks in bark, fissures in rocks, and similar spots, so the eggs were deposited in those places where a retreat could be constructed.



Theridiid webs commonly appear to be just a tangled, three-dimensional mass of non-viscid threads, although viscid silk is used in the swathing film wrapped around the prey. But it is now known that some members of this family include a number of vertical threads that extend from the sheet to the substratum, and that these have at the lower end a number of viscid globules that can function in snaring ants and other ground insects. A reduction in the theridiid web is shown by *Episinus* of Europe. Here the sheet and irregular mesh are absent, and in effect the snare consists of only two of these "gum-footed" threads connected transversely above to present an H-shaped appearance. The spider hangs from the crosspiece by her hind legs and holds her front legs down along the vertical threads.

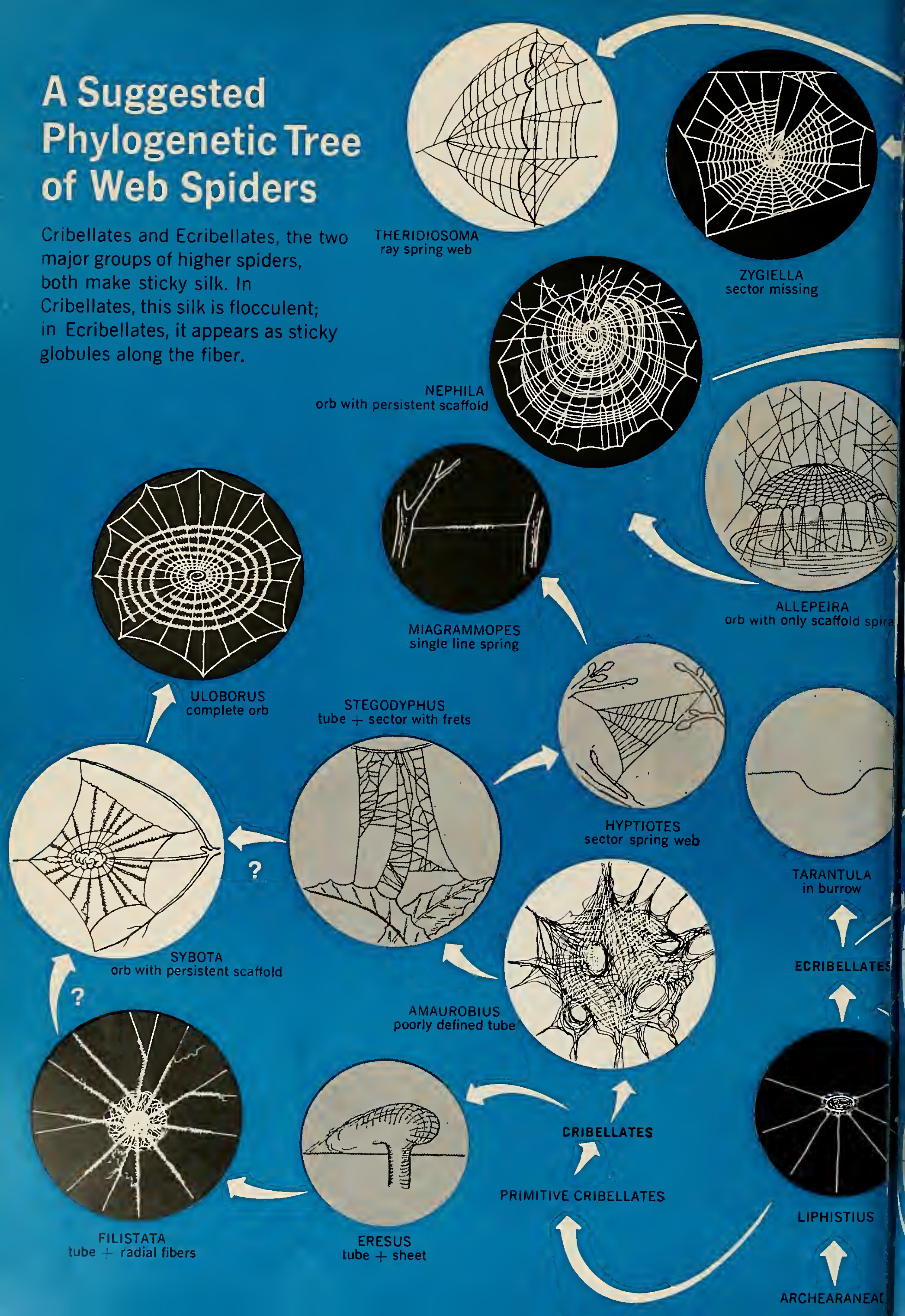
A still further reduction is that exhibited by a New Zealand theridiid, *Ulesanis pukeiwa*. Its web is made of a single thread, part of which is covered with viscid globules. The spider holds the thread taut, but jerks the line to entangle insects.

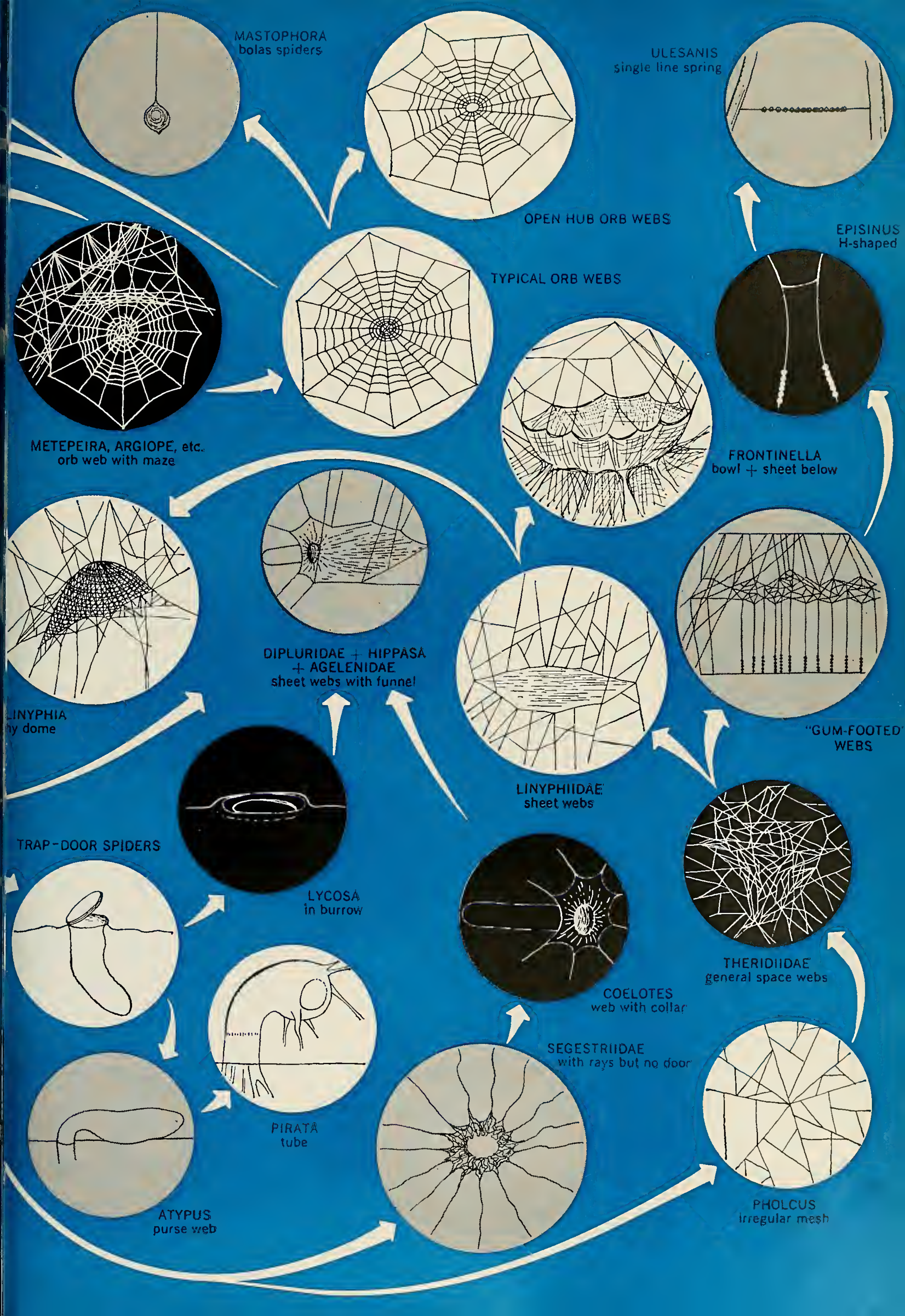
Finally, at what appears to be the end of the theridiid line of evolution, a few have divorced themselves completely from silk as a means of capturing prey. One example is *Euryopis*, which has no snare at all but lives under leaves and stones, having apparently reverted to the free-running hunting habits of its distant ancestors. Attention has already been called to the spitting spider, *Scytodes*, which has undoubtedly descended from ancestors similar to those of *Euryopis*.

We have seen how a sheet web may arise, and how in some cases the spider

A Suggested Phylogenetic Tree of Web Spiders

Cribellates and Ecribellates, the two major groups of higher spiders, both make sticky silk. In Cribellates, this silk is flocculent; in Ecribellates, it appears as sticky globules along the fiber.




MASTOPHORA
bolas spiders
OPEN HUB ORB WEBS
ULESANIS
single line spring
EPISINUS
H-shaped
TYPICAL ORB WEBS
METEPEIRA, ARGIOPE, etc.
orb web with maze
FRONTINELLA
bowl + sheet below
DIPLURIDAE + HIPPASA
+ AGELENIDAE
sheet webs with funnel
LINYPHIA
ny dome
"GUM-FOOTED"
WEBS
LINYPHIIDAE
sheet webs
TRAP-DOOR SPIDERS
LYCOSA
in burrow
THERIDIIDAE
general space webs
COELOTES
web with collar
SEGESTRIIDAE
with rays but no door
PIRATA
tube
ATYPUS
purse web
PHOLCUS
irregular mesh

constructs a stopping maze above the sheet. If no tube or retreat is present, the spider lives on the sheet, hanging upside down from its lower surface. The typical web of this pattern is the product of various members of the family Linyphiidae. In *Pityohyphantes* the web is a flat sheet spun between the twigs of a shrub or tree. *Microlinyphia* makes a horizontal platform between stems of grass, and spins a stopping maze above it. *Prolinyphia* makes a filmy dome, and *Frontinella* spins a bowl-shaped web, with an additional flat sheet below and a stopping maze above. There is a tendency, especially with the smaller members of the family, for the web to show a reduction of the tangles above and below the sheet. This is especially the case in the majority of the Micryphantidae that have taken themselves and their webs down from the bushes to the ground, where they spin delicate, small sheets across depressions and irregular places.

The evolution of orb webs presents the greatest difficulty, and the question of how the elaborate method of constructing one was acquired by the ancestors of today's orb weavers is not easy to answer. The ecribellate orb weavers are very close morphologically to the Linyphiidae, and there is some similarity in the appearance of the webs too. Observations on the actual construction of orb webs indicate that the spiral is spun from the center out. This, then, is in effect the scaffold spiral, although the turns are much more closely set than is usual for such a structure. It has already been pointed out that in the webs of young *Uloborus*, as well as adult *Sybota*, the scaffold spiral is the only one in the snare. It has been suggested that dome webs of *Cytophora* and *Allepeira* might be regarded as a stage in the evolution of the orb. The snares of these spiders have a stopping maze, the radii are numerous, closely spaced and so branched that the interval between adjacent radii is only slightly nearer the edge than the center. These characteristics are considered primitive.

In the webs of the present-day silk spiders, those giants belonging to the genus *Nephila*, we still find branching radii; also, the scaffold spiral is left in the finished snare, the spider placing several turns of the viscid spiral between any two turns of the scaffold. A further characteristic that is considered primitive is the presence of the stopping maze in the *Nephila* snare.

When this scaffold is lost as a permanent part of the snare, but the stopping maze is retained, we advance to the type of web made by many of today's orb weavers, especially *Metepeira* and *Argiope*. *Metepeira* constructs its retreat within the maze, but *Argiope*, the common garden spider of America, is found in the center of her snare, which is generally furnished with a stabilimentum. Finally, the loss of the stopping maze, or at least its great reduction (the spider depending on the sheet alone) leads us to the typical snare made by the majority of higher orb weavers.

But even here we have modifications, leading to several lines of further evolution. One of the best known is that in which the spider almost always (*Zygiella*). or very commonly (*Neoscona*), spins an incomplete orb, omitting the viscid spiral threads from one sector. The spider makes loops and swings back and forth many times instead of going completely around the web when laying down the viscid line. Then the animal takes up its station in a retreat off the web itself, but remains connected to it by a signal thread extending from the hub and sometimes virtually bisecting the open sector.

A second modification occurs in the spider that bites out the ends of the radii where they meet at the center, so that an open hub results. Such snares are built by *Meta* and *Cercidia*, by the members of the Gasteracanthinae, and by the Tetragnathidae. The gasteracanthines make close-meshed webs with many radii and spirals, while the webs of the tetragnathids have few radii and spirals and are thus open-meshed. Moreover, the latter are horizontal, a condition considered more primitive than the vertical. A reduction has occurred with the genus *Pachygnatha*, where no web is spun, although the spiderlings build snares.

A third modification is seen in the Theridiosomatidae. The snare of the ray spider, *Theridiosoma*, was first described by H. C. McCook, one of the most outstanding American students of spiders during the nineteenth century. This spider spins a reasonably typical orb with a meshed hub and several turns of thread in the attachment zone. It then bites these out so that the finished web has no hub or attachment zone, and the radii are rearranged to radiate from, and converge upon, a point near the center. These rays, coming from four or five main divisions, join to form a trap line attached to some nearby twig. The spider stations itself on the rays at the center and pulls the orb into the shape of a cone or funnel with its greatly thickened legs. The web is held taut, but the spider releases the tension when an insect touches the snare; the resulting spring action ensnares the prey more firmly. Here, then, is still another example of the spring web, already discussed for *Hyptiotes*, *Miagrammopes*, and *Ulesanis*.

The fourth and final modification is the loss of the orb-making habit in certain genera of the subfamily Araneinae, and the substitution of other techniques for obtaining prey. Perhaps the most remarkable of these is the bolas-throwing behavior of *Mastophora* in America, *Dicrostichus* in Australia. and *Cladomelea* in South Africa (NATURAL HISTORY, April, 1947). These spiders sit on, or suspend themselves from, a twig. They hold a thread, on the lower end of which is attached a sticky globule of silk, and fling it at passing insects. In *Cladomelea* the bolas is held by a hind leg and whirled rapidly in a horizontal plane. In the other two groups, the bolas is held by a front leg and is not whirled. Just how this behavior evolved from ancestors that undoubtedly were orb weavers, I cannot guess.

Another Australian spider, belonging to the genus *Celaenia*, is known to feed solely on night-flying moths, which it catches without the aid of either orb or bolas. From the published accounts it would appear that while the adult spiders wait in ambush and seize the moths by a lightning-quick movement of their legs, the spiderlings seem to construct snares. And so again we see, as with *Pachygnatha* and others, that the young revert to the habit abandoned by their adults. We find a parallelism for the structures built by the more primitive spiders (*Liphistius*, trap-door spiders, diplurids, tarantulas, etc.) and the more advanced (so-called true spiders), and again between certain Cribellates and certain Ecribellates. We also find parallels among much more closely related members of a large family group, such as the members of the highly advanced orb weavers.

ANOTHER orb weaver, *Metepeira*, makes its retreat within the stopping maze.

A PANDA PERFORMS IN PEKING

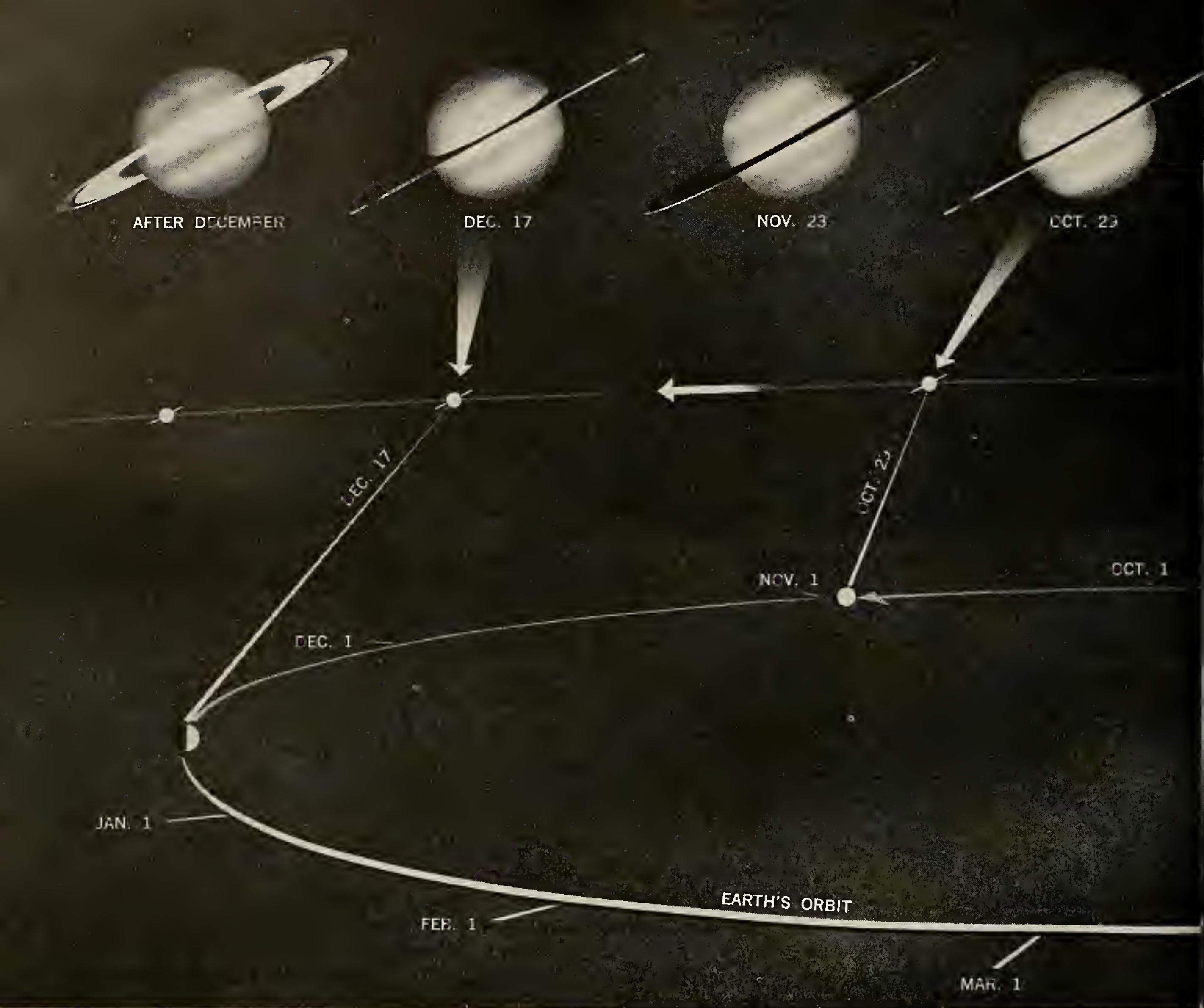
Pandas are among the most popular attractions at the few zoos fortunate enough to have them. Their teddy bear appearance and amusing antics as cubs endear them to children and adults alike.

The particular star here is a panda named Ling Ling who lives at the Peking Zoo. She is almost two years old, and is the second giant panda to be born in captivity. The first was her brother Ming Ming. Their parents, Li Li and Py Py, were brought to the zoo in 1957 and 1962, respectively, but refused to mate—so Ming Ming and Ling Ling were produced by artificial insemination.

Giant pandas (*Ailuropoda melanoleuca*) are typically black and white, and as adults may weigh more than 300 pounds. They have been referred to as "aberrant bears," although they are thought by some to be more closely related to raccoons. Recently they have been reported to live only in the mountains of the Chinese province of Szechuan and in eastern Tibet. Unfortunately for most zoo visitors, only four other giant pandas besides those in China live in captivity—one in London, one in Russia, and two in Korea.

Marc Riboud is a French photographer whose work is included in the collections of the Metropolitan Museum and the Museum of Modern Art.

Photographs by Marc Riboud



SKY REPORTER

This year earth passes through Saturn's ring plane three times

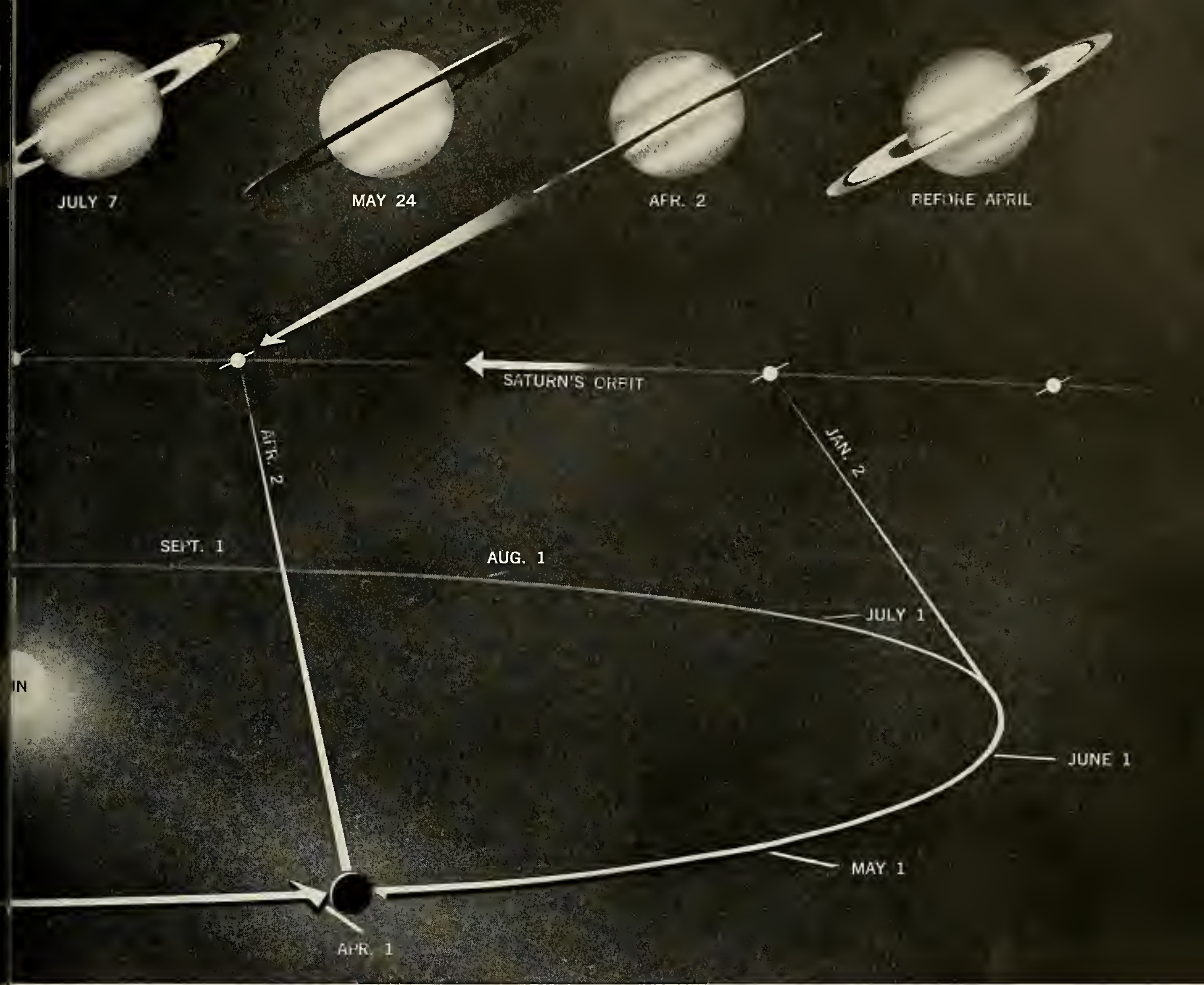
By Thomas D. Nicholson

Saturn has not been a conspicuous object in our sky of late. Last year, at opposition in September, it was an obscure object even among the faint autumn stars. Continuing as an evening star until late February, Saturn was in conjunction with the sun on March 10 and is now, in early April, beginning to appear as a morning star. This year, however, as it goes through its cycle as a morning star in spring and summer, opposition in mid-September, and an evening star in autumn and winter, it will be even fainter than it was last year, for the edges of Saturn's rings will be turned to the earth three times, the first on April 2.

The rings of Saturn contribute significantly to the total brightness of the planet as it appears in earth's sky. When the edges of the rings are toward earth, the magnitude of the planet at opposition is about +0.8, almost as bright as the star Aldebaran in Taurus. At those times when the rings appear open to their fullest extent, however, the planet at opposition will have a magnitude of —0.3, brighter than any star but Sirius and Canopus. The rings, in effect, nearly double the apparent brightness of Saturn.

Apart from their effect on the prominence of Saturn as a naked-eye object, the rings add materially to its interest as an object for telescopic viewing by amateur and professional astronomers. When the rings are open, they can be seen clearly with small telescopes or even binoculars.

When the rings are "edge-on" to the earth, they are far more difficult—often even impossible—to see. Then they appear as thin, almost threadlike, bright lines, sometimes uneven in brightness and length, extending across, and on either side of, the planet. When the rings disappear, their shadow may look like a thin thread of black through the otherwise bright planet. It is also at or near the time of ring disappearance that Saturn's bright inner satellites may be observed going through phenomena of transits and occultations similar to those regularly observed in the satel-



Edge of Saturn's rings will face earth on April 2, October 29, and December 17. Until June 15 (Saturn's autumnal equinox) the sun shines on the north face of rings; after June 15, the opposite surface of the rings is in the sunlight. The diagram shows the orbits of the earth and Saturn during 1966.

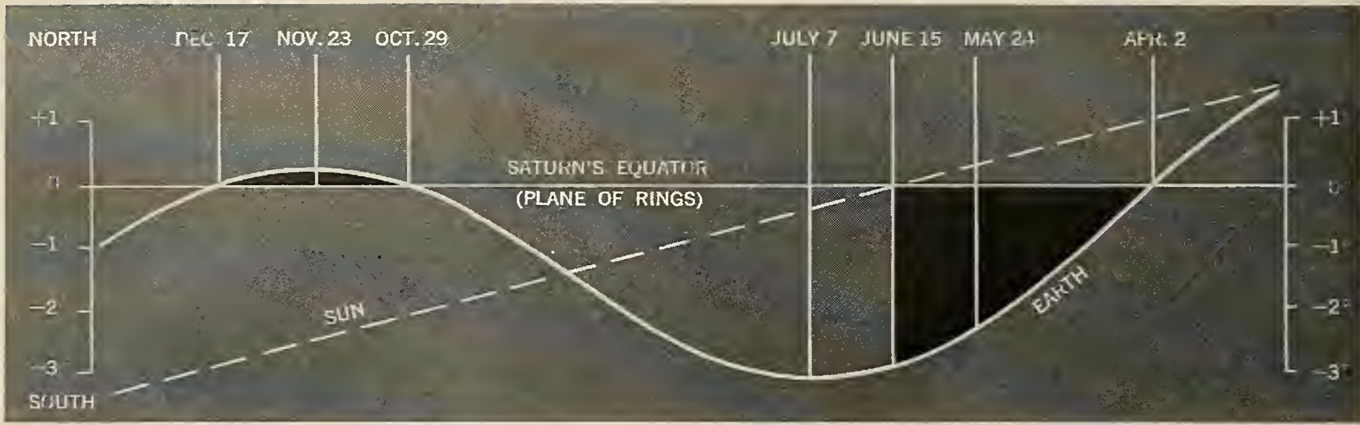
lites of Jupiter. Many amateurs may feel the planet is a disappointing object and ignore it, but the professional planetary astronomer and the serious amateur will regard 1966 as a year of opportunity for watching Saturn.

The periodic appearance and disappearance of Saturn's rings takes place in a cycle of about 29½ years, the period of Saturn's revolution around the sun. Saturn, like the earth, rotates on an axis that causes its equator to be inclined to its orbit by an angle of 26.7 degrees. Because the rings of the planet are located directly above its equator, they are inclined to Saturn's orbit by the same amount.

As Saturn revolves around the sun, it goes through seasons very similar to the earth's because of the similar inclination of their axes. The seasons are not accompanied by the same changes we experience on earth, of course, because Saturn is predominantly a gaseous world, nine times larger in diameter than the earth, with only a small, solid core of rock or metal—if it has any at all—buried beneath frozen gases tens of thousands of miles thick, surrounded by a few hundred miles of vaporous atmosphere.

The sun will be located directly over Saturn's rings when the planet arrives at what we might call its autumnal equinox—when it is located about 354 degrees eastward around the sky from the First Point of Aries (the earth's vernal equinox) as measured at the sun. As seen from earth, Saturn is then somewhere among the stars of Aquarius or Pisces. When Saturn arrives at its vernal equinox, halfway around its orbit, it is seen from earth among the stars of Leo or Virgo. It takes Saturn about 15.8 years (somewhat more than half its 29.5-year period of revolution) to go from vernal equinox to autumnal equinox; from autumnal equinox to vernal equinox takes about 13.7 years.

Consider how Saturn's revolution would appear if we could observe it from the sun. When the planet arrived at its vernal equinox, we would look directly down on its equator and see neither face of the rings. Thereafter, as Saturn moved eastward, the sun would shine north of Saturn's equator (since the *northern* spring and summer follow the vernal equinox), and we would look down on the sunlit, northern face of the rings until the sun was 26.7 degrees north of Saturn's equator. That would be the beginning of the northern summer on Saturn. We would continue to see the north face of the rings until the autumnal



POSITIONS of the earth (curved solid line) and sun (straight dotted line) are shown in degrees north and south of the plane of Saturn's equator and rings. Dark areas show period when earth and sun are on opposite sides of Saturn's rings.

equinox, which occurs this year on June 15. Then we would see neither face of the rings because we would again be over the planet's equator. After the autumnal equinox, when the sun shone over the southern hemisphere of Saturn, we would see the sunlit southern face of the rings until the beginning of winter, when the sun was 26.7 degrees south of Saturn's equator. Later we would still see the south face of the rings; they would be narrowing continually until they were edge-on and directly over the equator again in 1980.

The view of Saturn from the sun would be nearly the one we have from earth, except that we are separated from the sun so that we actually see Saturn from a varying position. In other words, as Saturn approaches its autumnal equinox on June 15, 1966, the earth will arrive in the plane of Saturn's equator at a time different from the sun. Because the earth's motion around the sun is so much more rapid than Saturn's, we can cross the plane of Saturn's equator three times while the sun does so once. Each time we cross over the planet's equatorial plane we will be looking directly at the edges of the rings.

THE three passages of earth through the plane of Saturn's rings this year are explained by the illustration on the preceding pages. As Saturn slowly approaches its autumnal equinox (at the rate of about one degree of arc along its orbit per month), its equatorial plane (and the plane of the rings) begins to sweep across the earth's orbit in early January. The earth, at that time, has just passed its winter solstice, at nearly the opposite part of its orbit, but is moving rapidly toward the advancing ring plane, from Saturn's north to south, even though the sun shines on the north side until June 15. After crossing through the plane of the rings, however, the earth swings round its orbit and, after June, begins to catch up to the ring plane again. The earth overtakes the plane, and on October 29 crosses from south of the rings to north again, although the sun has been south of the rings since June 15.

The earth rapidly moves away from the ring plane after October 29, but the direction of the earth's motion now takes it away from Saturn itself. The earth swings round to approach Saturn's ring plane once more just before the plane moves off the earth's orbit. On December 17, the earth again crosses from the north to the south side of the rings. Thereafter, both sun and earth remain south of Saturn's equator until the planet's vernal equinox, more than 13 years from now, in 1980. The last triple passage of earth through the ring plane occurred in 1920-21; at the next two equinoxes (in 1980 and in 1996) earth will pass through the plane thrice each time. This year, Saturn will still be near conjunction on April 2, the first time we pass through the plane. On the later passages the planet will be past opposition, but in a good position for observing.

The changes that should occur in Saturn's appearance this year are illustrated on pages 36-37. As the earth approaches the plane in April, the rings, still illuminated on the north side by the sun, should appear as a thin bright line on either side of the planet. On April 2, when they are exactly edge-on, they should disappear entirely, and the only sign of their presence should be their thin, slightly curved shadow on Saturn itself. After April 2, the sun will still be shining on the north face, so that in theory the rings should not be visible from earth. But a triple passage through the rings in 1907-8 demonstrated that the dark side of the rings can be seen, although they are somewhat pale and dusky in hue. There may also be local condensations of brightness in the unilluminated rings, specifically two bright areas on each side of the planet.

The phenomenon of the dark rings will last until June 15, when the sun begins to shine on the south side of the rings. From then until late October they should have their usual appearance, although they grow very thin toward the end of the period. The rings will again be edge-on, and will disappear entirely on October 29, when the earth crosses over to the dark northern side once more. Finally, the earth will recross the rings on December 17, over to the sunlit south side, and the rings will continually widen and, thus, brighten for the next seven years.

The source of light on the dark face of Saturn's rings has been explained as sunlight reflecting from Saturn to the shadowed rings, as sunlight filtering through the rings themselves, or as fluorescence from the material of the rings. None is a completely adequate explanation, however. Similarly, the bright areas seen amid the dark rings when earth is on the shadowed side have never been well accounted for. But, after all, these phenomena of the dark rings have only been observed twice in the past century. It has been forty-five years since we had the opportunity of seeing Saturn's rings under these unusual circumstances.

DR. NICHOLSON, the regular author of this column, is also Chairman of the AMERICAN MUSEUM-HAYDEN PLANETARIUM.

THE SKY IN APRIL

Full Moon	April 5, 6:13 A.M., EST
Last Quarter	April 12, 12:28 P.M., EST
New Moon	April 20, 3:35 P.M., EST
First Quarter	April 27, 10:49 P.M., EST

TIMETABLE

April 1	10:00 P.M.
April 15	9:00 P.M.
April 30	8:00 P.M.

(Local Mean Time)

April 2: Earth passes through the plane of Saturn's rings for the first time since 1950. Two additional passages through the ring plane will occur later this year.

Mercury, in the morning sky, becomes stationary in right ascension and resumes direct motion.

April 6: Venus reaches greatest elongation from the sun as a morning star (46 degrees west of the sun, magnitude —4.0). This is not a favorable elongation, however, for Venus rises only about one and a half hours before the sun and is only about 18 degrees above the southeastern horizon at sunrise.

April 9: Saturn, which entered the morning sky on March 10, may be seen together with Mercury this morning, close to the horizon in the east about an hour before sunrise. Saturn (magnitude +1.4) is below and to the right of the brighter Mercury (magnitude +0.9).

April 16: Venus and the crescent moon are always an attractive pair. They rise together this morning, with Venus to the left and above the upper horn of the lunar crescent.

April 17-18: The late crescent moon is in conjunction with Saturn at 3:00 P.M., EST, on the 17th, with Mercury at 4:00 A.M., EST, on the 18th. Look directly above the crescent moon before sunrise on the 18th to see Mercury—then look to the right to find Saturn.

April 18: Mercury reaches greatest elongation (28 degrees westerly, magnitude +0.6) in the morning sky.

April 22: The Lyrid meteor shower reaches maximum this morning. This is a relatively sparse shower, usually showing slow, faint meteors.

April 25: Jupiter, the only planet conspicuous in the evening sky, is in conjunction with the moon at 3:00 A.M., EST. Jupiter (magnitude —1.6) is to the left of the crescent moon on the 24th; to its right on the 25th.

April 29: Mars is in conjunction with the sun and moves into the morning sky.

All Month: Venus, Mercury, and Saturn are in the morning sky all month, but only Venus is bright enough, high enough, and rises early enough to be seen readily. Venus should be especially interesting about mid-month, when the moon is in the morning sky. Jupiter is an evening star throughout the month, and is in the western sky until almost midnight.

Covered courtyard, above, is located at Mexico City's National Museum of Anthropology.

Figures on high stools, as one at right, are rare. Left hand is holding a bag for copal incense.

Clay Sculpture From Jaina

ISLAND BURIAL SITE YIELDS MAYA TREASURES

By Luis Aveleyra Arroyo de Anda and Gordon F. Ekholm

Jaina (pronounced HY-nah) is a small, low, mangrove-bordered island lying just off the gulf coast of Mexico, thirty miles north of the city of Campeche. Roughly a square mile in size, it is separated from the mainland of the Yucatan Peninsula by a channel about 150 feet wide.

Unimpressive in size and appearance as it is, Jaina is a world-renowned archeological site of the ancient Maya, and is specially famous as the source of great numbers of those minor Maya masterpieces known as Jaina figurines. These beautifully executed little figures of the Mesoamerican Classic Period have been recovered from innumerable burials that are found there, for the island is a great cemetery of simple, shallow graves in which pottery vessels and ornaments, in addition to the figurines, were placed with the bodies. The island is unique among Maya sites, for even in those that boast magnificent buildings and great stone sculptures, graves are not often discovered, and complete clay figures are rarely found. More well-preserved Maya figurines have come from Jaina than from all other Maya sites combined.

Despite its archeological riches, Jaina has been little known to the archeologist. Although hundreds of the figurines can be found in museums and in private collections, they have, for the most part, been excavated by illegal diggers and disposed of through commercial channels. This grave looting has been going on for a long time; the French explorer Désiré Charnay, who in the 1890's provided the first published account of Jaina archeology, reported that the island was then being dug into by treasure hunters. Undoubtedly this has continued intermittently, but

the phenomenal growth of interest in pre-Columbian art during the last thirty years has caused an acceleration in the ransacking of the island by commercial diggers.

It may seem strange that Jaina has received so little archeological attention in the past, but it must be remembered that it is only one of a tremendous number of Maya sites, and that many major problems of Maya archeology can be attacked in other places to greater advantage. Jaina has also been a difficult place to reach and to work. There are no roads by which one can approach the island by land, the most feasible route being by canoe from Campeche. All drinking water and other supplies must be brought in the same way, although one could depend for food on the plentiful fish that are easily caught in the vicinity. Despite its inaccessibility, several groups of Mexican archeologists investigated the site for short periods in 1941-42, and later in 1947 and 1957, but all were working with limited facilities and personnel.

The most recent expedition to the island, and the one that has accomplished the most extensive work there, was a by-product of the planning and building of the magnificent new National Museum of Anthropology in Chapultepec Park in Mexico City. The museum was an all-out effort by the Mexican government to establish a new and adequate center for its extraordinary archeological treasures and for studies relating to the country's many native Indian groups. Architect Pedro Ramírez Vásquez, designer of the new building and head of the council created for planning the museum, realized the need to enrich the collections. He helped to send out several archeological and ethnographic expeditions to make possible full coverage of all aspects of Mexican anthropology.

Jaina was an obvious choice as a source for enriching the museum's exhibition materials, and the expedition sent there remained in the field from mid-April to mid-June of 1964. Equipment and supplies, a powerful motorboat, and a barge were provided. A modern camp was established by setting up several prefabricated steel structures and by constructing large water-storage tanks. The installation, which has accommodations for fourteen persons, includes a kitchen, dining room, laboratory, and storerooms, and was designed both to accommodate this expedition and to be a permanent structure for future use by archeologists. It also furnishes quarters for the guards who remain in residence to protect the site from further depredation by clandestine diggers.

The expedition was conducted by the archeologists Román Piña Chan, who was in direct charge of the field activities, and Luis Aveleyra Arroyo de Anda, at that time Secretary General of the museum planning council. Two physical anthropologists, Roberto Jiménez Ovando and Sergio López, collaborated in the excavations and undertook the preservation of skeletal materials. Fifty laborers were hired for excavation work; twenty others were employed as cooks, fishermen, and administrative and maintenance personnel. With this staff it was possible to excavate extensively at several places on the island.

Nearly four hundred burials were methodically explored during the season. They provided an invaluable corpus of information on burial customs, and the largest and most spectacular collection of figurines and other objects, as well as osteological materials, ever gathered at Jaina. This great amount of excavated material awaits detailed classification and study, and should result in a new understanding of the sequence of grave and artifact types and of the history of the site's occupation. It is most important that precise information on the associations of various types of objects in graves will now be available.

The people of ancient Jaina deposited their dead directly in the ground, the body either extended full length or, more frequently, in a flexed or natal position, with knees drawn up to the chin. In nearly every instance a heavy tripod ceramic bowl was inverted, as if protectively, over the head. In some cases the body was painted red with iron oxide, indicated by remnants of this durable paint adhering to the bones. Occasionally a jadeite bead was placed in the mouth. Many kinds of funerary offerings are found with the skeletons, including pottery vessels of various kinds, ornaments and necklaces of stone and shell, and generally one or more of the terra-cotta figurines that have made Jaina so justly famous—the latter usually on the body's chest or arms. The infant dead were placed inside large pottery jars with inverted tripod bowls serving as lids. Many of the finest figurines were found with this type of infant burial. The skeletons at Jaina indicate that these people followed the usual ancient Maya custom of deforming the skull—a method of modifying the shape of the head by the application of pressure during infancy—and that tooth mutilation was in vogue. The incisors were filed in various ways; sometimes their outer surfaces were inlaid with small disks of iron pyrites or of semiprecious stones.

The quantity of graves on the island is nearly

d-modeled figurines show a warrior with shield, ve; a priest, right, seated in a ceremonial pose; and players, below, wearing protective belts.

Unusual standing figurine, above, has a detachable headdress. Clothing of the woman, below left, probably denotes high rank; figure at right has movable arms.

unbelievable, for while working in only relatively small areas the expedition excavated four hundred of them—a number limited only by the time available. Considering the large areas still untouched, it is conservatively estimated that there must be more than 20,000 burials still remaining. This is most remarkable in view of the large numbers that must have been rifled over the years by the treasure hunters. To everyone's surprise, however, these grave robbers have been able to accomplish only minimal damage, simply because of the incredible volume of material available.

The figurines that appear in the burials are of great variety and of extraordinary interest. Most of them represent human beings in ceremonial regalia, much like the figures on Maya stone monuments. There are warriors, ball players, priests, and perhaps deities dressed in robes and high, elaborate headdresses, decked in all the symbolic accouterments of their religion. There is far more freedom of representation, however, than was apparently allowed in the supposedly stricter conventions of stone carving, and we find realistically modeled animals and men and women in a variety of poses, often simply dressed and occupied with what can only be described as everyday activities. A great many of the figurines accent the more human qualities that are usually absent in Maya art.

The figures are made of a fine clay, fired to a light tan or pink color. A majority of them are moldmade by the use of a single-piece mold that served to fashion the entire front surface. The back was probably applied when the front was still in its mold by fitting onto it a thin sheet of clay and welding it around the edges, leaving a hollow interior. Often there were pellets of clay left inside this hollow to make the figurine into a rattle, or in some cases, cuts or perforations transformed it into a whistle. Other figures were made entirely by hand modeling, or the faces were moldmade while the bodies and headdresses were individually modeled and attached. The figurines were often covered with a white slip—an over-all coat of liquid clay—before firing, and then were painted with brilliant colors. These colors are often preserved and add greatly to the beauty of the objects.

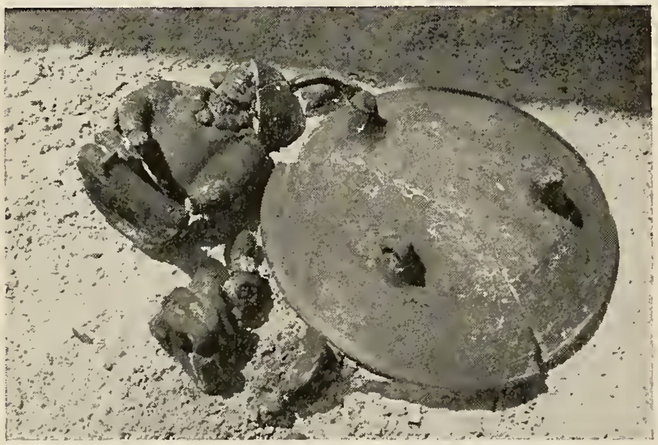
It is the hand-modeled pieces that are the high point in Jaina figurine art. Here the artist could develop his forms with great freedom—as is apparent in some of the examples illustrated here. It is easily understood why these figurines are the most coveted by collectors and museums. Certainly they compare favorably in interest and esthetic quality with the elaborate Tanagra figurines of Classic Greece or the best of the clay sculpture of early Egypt or China.

Area that once was Jaina's ceremonial plaza is delimited at each end by high structures.

Jaina has become so famous for its burials and its figurines that little attention has been paid to the fact that the island also supports a good-sized Maya ceremonial center. There is a large plaza surrounded by a number of mounds, and preliminary tests have shown that these contain temples and other buildings in which there are indications of several phases of construction. There are two higher mounds, known as the Zacpool and the Zayosal, that must have been the principal temples, the larger Zacpool being about sixty feet high. There are few standing walls, however, and nearly all of the buildings have been divested of their stone facings. Some time earlier in this century the island was occupied by an industry engaged in the burning of lime, with the ruins serving as convenient quarries. Limestone was available in small-sized pieces that had been used in the ancient buildings. The burning of limestone to produce lime was facilitated by the fuel at hand in the mangrove wood that could be cut on the island or along the shore of the mainland.

It is difficult to know just how to interpret the archeological remains of Jaina. While this location on an island could mean that it was a fishing and perhaps a trading station for coastal canoe traffic, it is unlikely that these were its primary functions, because of the presence of the ceremonial buildings and the extensive burial grounds. It appears more probable that Jaina was, at least in part, a kind of mecca for the deceased, and that the dead and perhaps the dying were brought from the surrounding country of the mainland for burial in a place that was

Usually one or more figurines are found in grave; jade bead was often placed in mouth of the deceased.



Two figurines and broken pottery vessels are shown in excavation as they were found with a skeleton.

This arrangement of a bowl over the skull, with a figure next to an arm bone, is typical of Jaina graves.

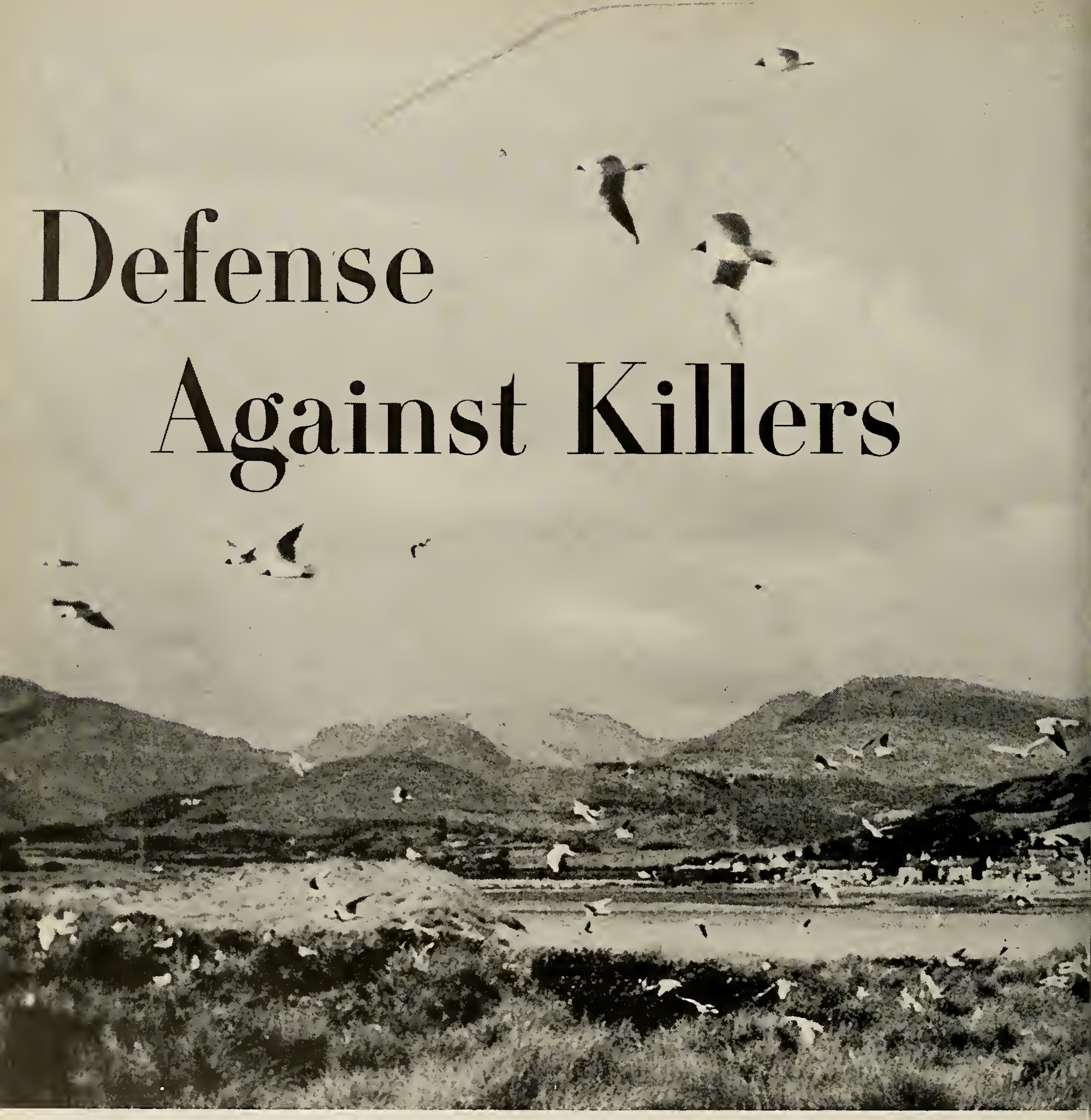
thought to be specially sacred or favorable. This would be consonant with practice in other areas in Mesoamerica where special reverence was seemingly accorded to particular bodies of water or islands. Such a hallowed site is the sacred *cenote,* or natural well, at Chichén Itzá, famous as a place of sacrifice. Evidences of similar rites are found in the numerous ceremonial vessels that have been recovered from Lake Atitlán in Guatemala. We know too, from historical accounts, that at the time of the Spanish Conquest, the Isla de los Sacrificios—in what is now the harbor of the city of Veracruz—was a place of reverence, and that pilgrimages were made to it from distant points. In a similar fashion, Jaina may have figured in a form of water cult that was of greater importance at an earlier date than it appears to have been at the time of the Spanish invasion. Whatever its function in Maya society, Jaina was occupied only during the latter half of the Classic Period and perhaps to some extent into the Post-Classic. This would span the period between the sixth and the tenth or eleventh centuries A.D.

Despite the recent studies, many questions remain concerning the Maya occupation of the site. It is uncertain, for instance, if the island is a natural formation or if it was built by man. There are some geologists who have suggested the latter because the island is underlain by a thick layer of white, sticky marl, perhaps composed of what is known locally as *sascab.* This is a soft, crumbly form of unconsolidated, limey material found in cavities in the Yucatan limestone and used by the Maya in their construction work. Certainly, huge quantities of limestone were brought from the mainland for the construction of the buildings, and, if a good portion of the island itself is artificial, Jaina saw the expending of tremendous amounts of human labor. There are also traces of what might have been a stone bridge crossing the channel that separates the island from the mainland, but they have not yet been investigated.

Obviously much remains to be done at Jaina before all aspects of its culture are known and its role in the florescence of Maya civilization is fully revealed. Through its miniature clay sculptures, however, it has already provided a greater visual understanding of the appearance and activities of the ancient Maya people than have the materials from any other Maya site.

Great emphasis was placed on elaborate headdresses, necklaces, and other ornaments.

Defense Against Killers



Gulls protect themselves against ground and aerial enemies

By Hans Kruuk

One of the important components of the theory of evolution is natural selection, which results in the differential survival or breeding advantage of individual animals. And, obviously, one of the most direct means by which natural selection operates is predation, which in a consistent way leads to the destruction of certain animals.

If predation is indeed important as a selector, one would expect that among the characteristics a species acquires in its phylogenetic history, the means of defense against potential predators would be highly developed. Thus, we have the basic elements for an interesting interaction—the predator with its specific killing methods and the prey with its defenses.

Some years ago, when I was working under the supervision of Dr. N. Tinbergen in a large colony of Black-headed Gulls in the north of England, we became aware of the possibilities for a predation study in such a colony. Dr. Tinbergen reported i[n] Natural History, August-Septem[ber], 1963, how these gulls carry awa[y] the empty eggshells after the chick[s] hatch, and that the main function o[f] this response was very likely protec[tion] of the brood against predation b[y] crows and Herring Gulls. We als[o] found that they possessed many othe[r] protective mechanisms. On the othe[r] hand, we consistently found gull[s] killed by foxes or other enemies, egg[s] taken, and chicks carried off, and [it] was clear that although the gulls ha[d]

Sand dune peninsula on north England coast is the nesting site for some 8,000 pairs of gulls. A young chick, *inset*, is easy prey for fox, crow, and hedgehog.

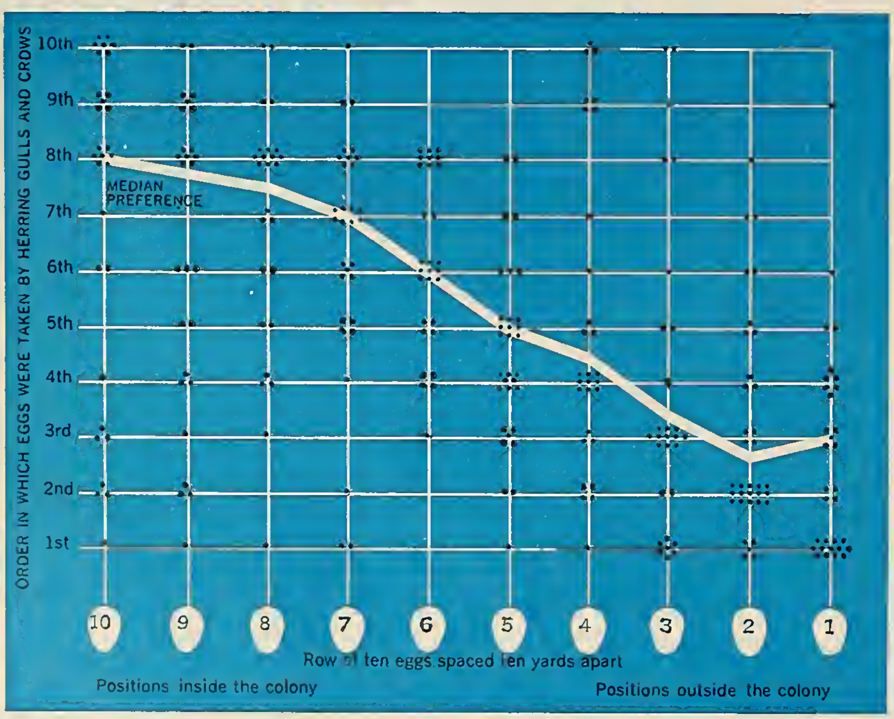
some sort of defense, their predators managed to break through it. Through my observations I became extremely interested in the gulls' antipredator system as a whole, and decided to make a study of it.

For a start, I split up the problem into a number of questions. First, what are the enemies of the Black-headed Gull; what are their methods of predation; and how much damage do they do? Second, what are the gulls' reactions to these different enemies? Especially, what is the effect of these reactions on the predators? Do they, in other words, have survival value?

The colony of Black-headed Gulls with which we worked is beautifully situated on a sand dune peninsula in the Irish Sea off the Cumberland coast near Ravenglass. Although this species habitually nests in marshes or on floating vegetation and other inaccessible places, in this colony about 8,000 pairs nest on the dunes along the edge of the peninsula. Fortunately, this choice of habitat in Ravenglass makes observations relatively easy. Moreover, the gulls' breeding sites are surrounded by sand on all sides, providing a marvelous opportunity for studying the tracks of nocturnal visitors to the colony. Apart from Black-headed Gulls, the small peninsula also accommodates many other species of birds—there is a colony of Sandwich Terns, dozens of oystercatchers rear their young, and a number of other species are abundant.

Several kinds of animals prey on the gull colony, and I found it convenient to divide these predators into four groups. The first two are aerial predators, such as the Carrion Crow

Preparing to flee from an aggressive member of the colony, Black-headed Gull assumes a posture resembling one it shows when threatened by predator.



Dots represent order in which eggs were taken from row extending inside and outside the colony. Outside eggs were usually taken first: bottom right cluster shows that in thirteen cases the egg in position I disappeared first.

and the Herring Gull, which may prey on the brood, and the harriers and the Peregrine, which may be a danger to the adults. Then there are two groups of ground predators: one includes hedgehogs, which prey on the brood only, and the other includes foxes, stoats, and humans, which eat both brood and adult Black-headed Gulls.

Of the aerial predators, the most common in the Ravenglass colony are the Carrion Crow and the Herring Gull. Oddly enough, however, although there are many crows on the peninsula, we seldom saw them actually disturbing the gulls. In fact, in their flights about the peninsula they sometimes make large detours around the breeding sites. We found this contrary to our expectations, as crows are generally known to like birds' eggs and chicks. But a simple experiment soon showed what was happening. Just outside the breeding area we made a small "colony" of sixty gulls' eggs, whose main difference from an actual gull colony was the absence of adult birds. Within a few hours, the crows had cleared every egg from the artificial colony. From a blind we saw that predation was mainly by a few individuals that either ate the eggs on the spot or carried them off to bury them in the dunes. Thus it appeared that crows can be a serious danger to the gulls' broods by taking large numbers of eggs in a short time (far in excess of their immediate needs), but that the presence of adult gulls on the breeding sites deters the birds from asserting this pressure.

Herring Gulls act quite differently. In Ravenglass, a few solitary pairs of resident Herring Gulls breed among the much smaller Black-headed Gulls, and for a great deal of the breeding season subsist mainly on Black-headed Gull eggs and chicks. Especially around hatching time, pairs of Herring Gulls can be seen circling over the breeding areas, looking down, hovering, then swooping into the colony in an attempt to snatch away a young chick or egg. They never cache their prey, however, and in this way predation capacities of Herring Gulls are much more limited than those of crows. It was interesting that big flocks of migrant Herring Gulls, usually immatures, stayed around the Black-headed Gull colonies without showing any special interest in them, and fed entirely on mussels and crabs. Only the few resident pairs

Carrion Crow, as name implies, feeds mainly on gull corpses, but also eats eggs. Because of gulls' defenses, the crows seldom venture inside the colony.

Crow tracks are faintly visible near shell of egg stolen from gull colony.

showed a feeding specialization toward the Black-headed Gulls.

The manner in which the Black-headed Gulls react to Carrion Crows and Herring Gulls depends greatly on the behavior of the predators—for instance, whether they are flying, alighting, or sitting on the ground. When one of the predators flies over the breeding sites, the gulls on the ground beneath the flight path may fly up and away, making a small circle in the air before realighting on their territory. They may also pursue the predator, trying to seize it with their bills or strike it with their feet while uttering their raucous "tremulous" call. Their reactions to both predators are basically the same, although there are clear differences. Some gulls usually attacked the crows, but in more than two-thirds of our observations the crows managed to drive the gulls off. Herring Gulls in the air, however, are often ignored entirely; only seldom do the Black-heads attack them or flee from them. As soon as either of these enemies stalls in the air over the colony, often the prelude to a descent, a wave of tremulous calls goes through the birds below and many of them fly up toward the predator. If the predator then alights in the colony, the gulls nearby react by repeatedly swooping at it, often striking it with their feet. We found that on the ground the Herring Gull is attacked more frequently than the crow, a pattern that was confirmed by experiments with mounted models of both predators.

Having seen the few actual predation attempts of crows, the attempts of Herring Gulls that so often failed, and the complicated reactions of the Black-headed Gulls, we wanted to know if the differences in predation success of crows and Herring Gulls are caused by differences in their reactions to the Black-headed Gulls, or by variations in the reactions of the gulls to their tormentors. I sought answers to these questions by a series of experiments that aimed at standardizing the observations without interfering too much with the natural situation. Rows of ten eggs were laid out from a point outside the colony to a point inside, with the eggs ten yards apart. By watching from a nearby blind, I found that these egg lines were heavily preyed upon by crows and Herring Gulls, especially in the time before the gulls had themselves laid eggs. The predators would discover the eggs, and both species could be seen circling over them for a short time, alighting near one, eating it on the spot, or flying away with it.

But the outcome of such a predation attempt was not always successful; more often than not some Black-headed Gulls attacked the predators while they were alighting or after they had reached the ground. In these cases, the enemy might fly off without taking the egg. I noted the sequence in which eggs were taken by recording the theft with a 1 if the egg was the first one taken in an experiment, giving the next egg a 2, and so on. In

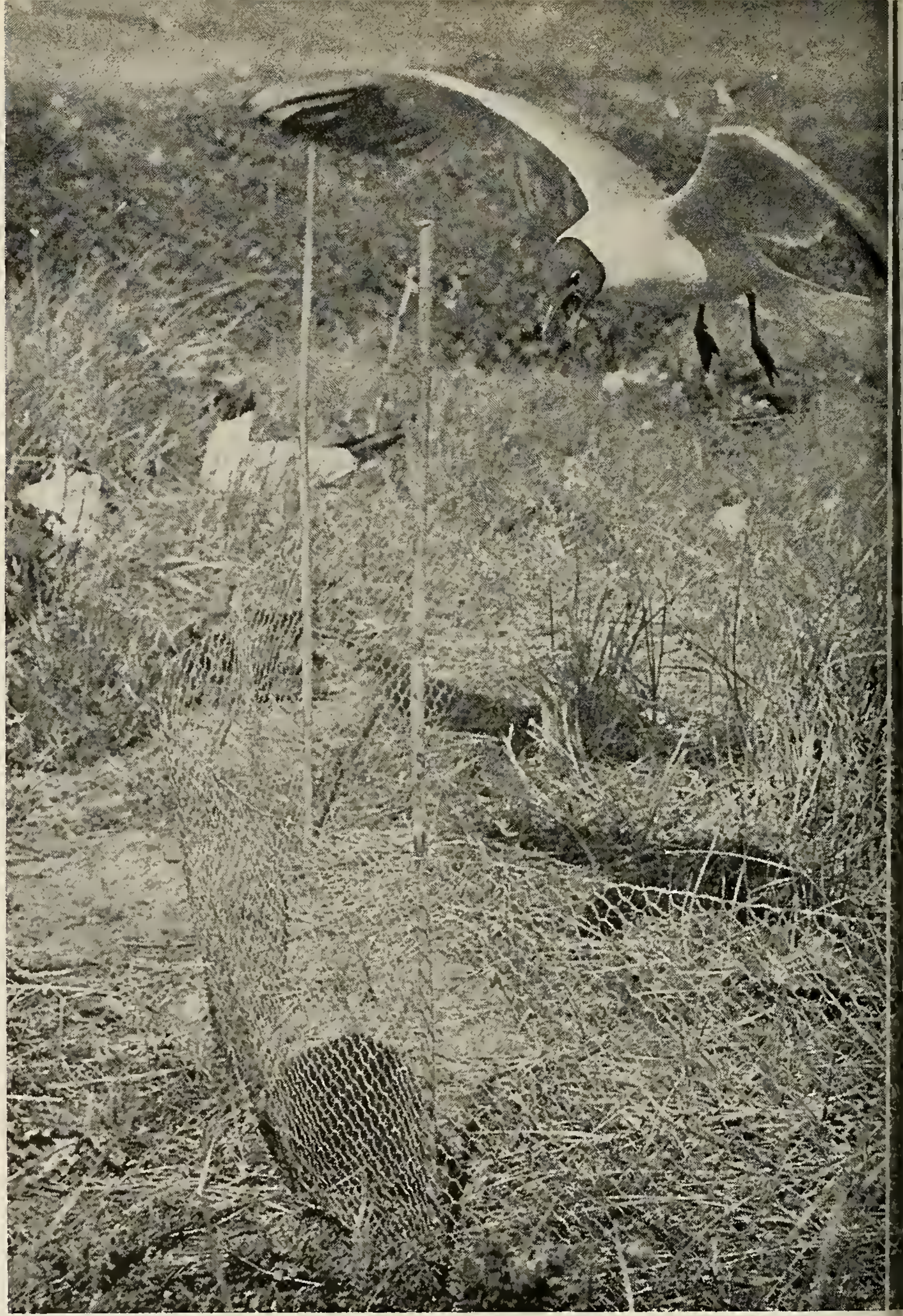
plotting this, it was obvious that both crows and Herring Gulls preferred to take those eggs that were farthest away from the breeding sites of the Black-headed Gulls. I repeated the experiment in the same place *before* the gulls had arrived on their breeding grounds, and at that time the eggs were taken in random fashion. Here, again, appeared the protective influence of gulls on predation.

Did the attacks of the gulls deter the aerial predators? Every time a predation attempt took place, I recorded the number of attacks made on the predator and whether the attempt was successful. A negative correlation emerged between attack frequency and predation success, so this was at least part of an explanation: Black-headed Gulls' attacks actually deterred the marauders and appeared to deter crows more than Herring Gulls.

Another category of aerial predator—raptors like the Peregrine and the harriers—was relatively rare in the Ravenglass colony. The gulls invariably reacted to them by flying up and away in dense flocks, zigzagging low over the beach at great speed. I never saw a gull attack a Peregrine, but some gulls did pursue harriers. The Peregrine is an especially large consumer of adult Black-headed Gulls, but will never take any broods. Birds such as harriers do take young gulls, and also present a great danger to the adults. Crows and Herring Gulls only endanger eggs and young. Comparing the reactions of the gulls to Peregrines and harriers with the relation between Black-headed Gulls and crows or Herring Gulls, we see the way in which the gulls' behavior has been adapted to cope with predation: they flee if a potential danger threatens the adults, and they attack if the enemies are after the brood. This adaptation becomes even more evident when we observe the gulls in relation to the threat of ground predators.

GROUND enemies were far more numerous in Ravenglass than we expected. Every morning the tracks of six to eight hedgehogs were found in the sands around the colonies, and when I analyzed the feces found in the tracks, it appeared that a good 30 per cent of the hedgehogs' diet in this location at this time of year consists of eggs and chicks of Black-headed Gulls.

Gulls' nests often were marauded, and hedgehog tracks told a clear story.



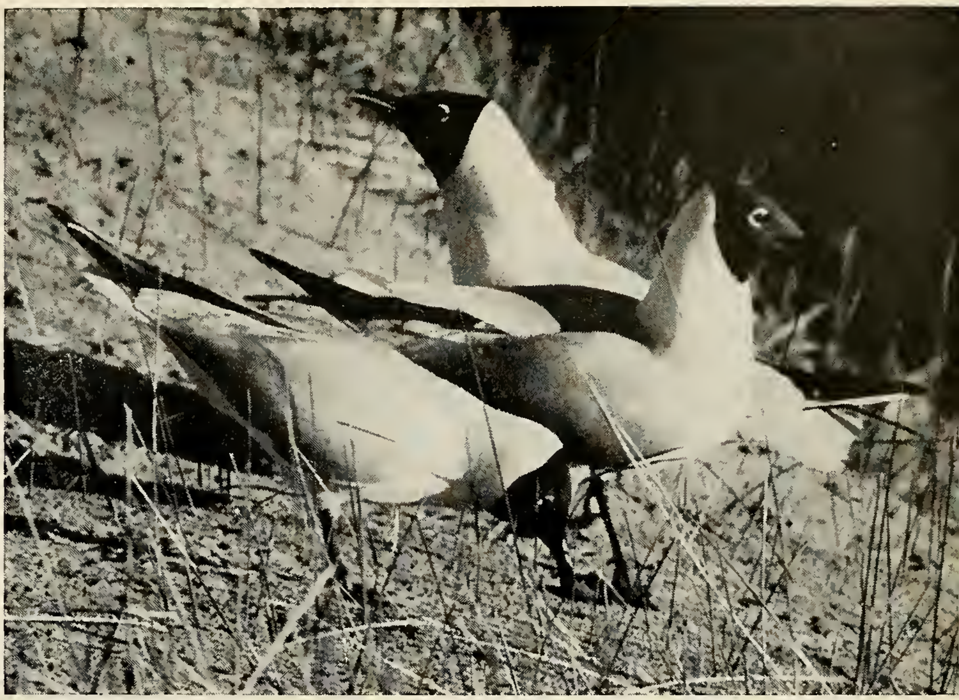
GULL, *above*, defends its brood against hedgehog put in enclosure for study.

HEDGEHOG, *below*, is slow and small but can eat many eggs and fledglings

From our figures on the hedgehogs' diet and their population size we estimated that each season 2 to 3 per cent of the gulls' broods in Ravenglass were destroyed by hedgehogs. The ability of the hedgehogs to deal with big gull chicks was surprising. They sometimes attack even fledged ones, which are larger than the predator itself. The hedgehogs seize these chicks while they sit near their nests at night, and post-mortems show that the hedgehog grabs its victim anywhere it can with a powerful bite, and then starts eating it from the rear end. It sometimes eats only the large preening gland of the young gull, but usually it gnaws a hole through the pelvis and eats the intestines as well, sometimes leaving only the head of the chick.

The hedgehog is nocturnal, and although it cannot be called a quick mover, it covers large distances during foraging trips. This makes systematic observations of their interactions with the gulls rather difficult, and I found that it was necessary to create a more controlled situation. A large enclosure was built inside the gull colony, in which about twenty-five pairs of gulls nested. A blind was placed at the edge so that I could watch the nightly activities of the hedgehog that also lived inside the enclosure. As soon as it became really dark, the predator would emerge, and scuffle rather slowly through the vegetation. It would approach the nest of a gull and, depending on the bird's reactions, either turn back or climb on the nest (the owner of which had by then jumped off), and start to eat the contents.

When one of the hedgehogs approached a nest, the sitting bird usually started uttering tremulous calls while the predator was still three to six feet away; if the predator approached nearer, the gull assumed a typical attack posture, in which head feathers are raised, wings are lifted, and the open bill points slightly downward. The gull would then leave the nest, perhaps attacking the intruder with pecks or short swoops, striking the hedgehog with its feet and sometimes its bill. Between the tremulous calls, some birds utter the "kek" call, which is usually associated with fleeing behavior and these particular birds do not attack the predator. It appeared that these less aggressive individuals are those that lose their broods to hedgehogs—an example of selection pressures at work!



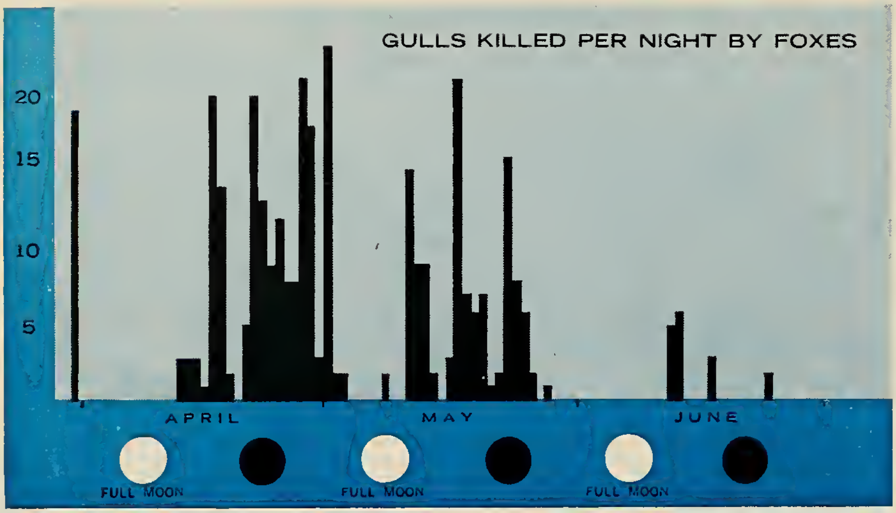
DISPLAY posture is part of a typical courtship ritual. Other gull species may employ a distraction display that diverts predators from nesting sites.

FROM an analysis of feces, we surmised that as soon as the gulls begin occupying the breeding colony in early spring, they become an important item in the diet of foxes in the area—up to 67 per cent of it in some months—although the proportion of rabbit still remains high. The abundance of gull bodies is striking at this time, and it is usually not difficult to show that they have been killed by foxes that then discard their victims without eating them. From 1961 until 1963 a total of 1,449 adult gulls was found killed, and portions of only about 40 of these had been eaten (although a number of gulls must have been consumed completely without any traces being found).

What is the function of this "surplus killing?" Many authors have commented on the foxes' habit of burying food that is not eaten immediately and their tendency to return to their caches. In Ravenglass, however, only a small percentage of the surplus kill is cached, and there are few indications that foxes utilize these caches (or any of their surplus kills) to any extent. On the other hand, the gulls' eggs are treated differently, and are sometimes buried in considerable numbers. Dr. Tinbergen found that many weeks after the gulls had left the breeding area foxes were still eating their egg caches. We can only assume that the surplus killing of gulls indicates a mechanism that may be highly adaptive when food is not abundant, but that "misfires" in this context.

Foxes emerge, then, as the greatest predators on Black-headed Gulls, mainly because the number of birds they kill is not limited by the quantity they can eat. The manner in which the gulls react to them is highly dependent upon the time of day, the darkness of the night, the behavior of the predator, and so on. If a fox arrives in the colony during the day, the gulls within a hundred-yard area around the animal desert their nests. Once the predator stops, many of the gulls return, and the deserted section shrinks to about eight yards from the fox. Some birds fly up and gather in a dense crowd above the fox, uttering both the aggressive tremulous call and the timid kek call, and many of them swoop down on the enemy. Rarely, however, do they come near enough to hit it.

On moonlit nights the gulls' response contains a much stronger element of fleeing. They fly up at distances of several hundred yards from the fox, flying high and not swooping down at all; this behavior may be set off by the reactions of other gulls to the fox. On dark nights, however, the gulls do not respond to the predator. At these times the fox walks quietly from nest to nest, killing its victims and dropping them in the same place. One night 230 gulls died this way.



Graph shows that foxes kill, on the average, more gulls during a moonless night than during one with full moon. Amount of overcast is also important.

The effectiveness of the reactions of gulls to foxes is indicated by the relation between visibility at night and the number of gulls killed. The night on which the 230 gulls were killed was a moonless one, with heavy clouds and rain. Fewer gulls were killed on clear nights with a full moon—and often there were no mortalities at all.

Stoats are known to prey on both adults and broods of the Black-headed Gull, and we often saw them near the Ravenglass colonies. The gulls react to them as they do to the fox, but they fly up from shorter distances and flock much lower over the stoat. When swooping at a stoat they often hit it with their feet, and this behavior is so effective that stoat predation on Black-headed Gulls is negligible.

The gulls' reaction to man is much the same as their reaction to the fox, except that they fly up in a slightly larger radius around the human invader. If a human carries a stick, the attacks are less frequent and at a greater distance.

To get more standardized information on the gulls' reactions I used stuffed models of the most important ground predators in several experiments. In this way it was possible to obtain accurate quantitative data that confirmed entirely the data I had collected in the natural situation. The whole complex can be summarized as follows: individual gulls attack the hedgehog most frequently and the fox least frequently, leaving the stoat in an intermediate position. But they will fly up for a fox and attack it over a much larger range, so that at any point in the colony a fox receives more attacks than a stoat, and a stoat receives more than a hedgehog. In the same sequence, however, the vigor of attacks increases, and whereas a hedgehog is hit or pecked often, the attacks seldom come close enough to score a hit on a fox. Thus it is apparent that the behavior against hedgehogs is mainly characterized by aggression but that fleeing elements become important in reactions to the stoat, and even more to the fox and man—although they are also attacked.

This behavior can be correlated

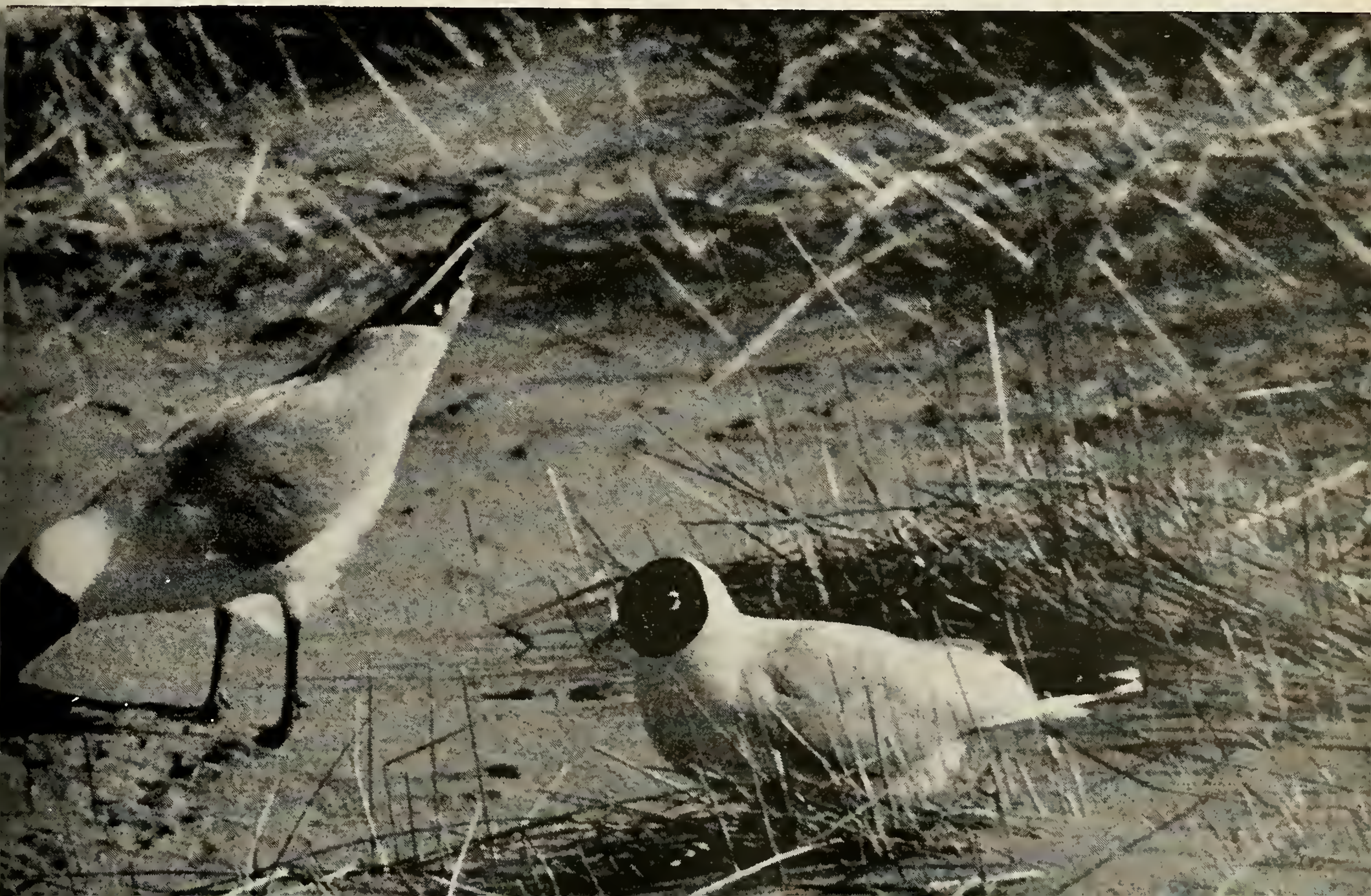
/ith the importance of these ground redators just as it can for aerial redators: hedgehogs are a menace to he broods; stoats could be a danger o the broods and also to adults; and oxes prey heavily on both adults and roods. The gull defends its brood by ggression, and defends itself and the rood by a combination of aggression nd fleeing behavior. It defends itself lone (as against the Peregrine) by leeing. So the reactions to all preda-ors seem to contain the same ele-nents: fleeing and some aggression re always present. The varying scale f reactions to different predators is rought about by the relative strength f these elements in each behavior pat-ern, and considered in this light, we an see that the gull's behavior is opti-nally adapted to deal with its enemies.

VICTIM of a fox, this Black-headed Gull was killed while it sat on its nest and then was left uneaten. On a dark night. hundreds may be killed.

WE are at a point now at which we must take into account many ther aspects of the birds' ecology. Its behavioral antipredator system is only complementary to its social nesting habits, breeding synchronization, hab-tat selection, and so on, and although he direct reactions to the presence of an enemy serve to influence the out-come of a meeting with that enemy, hese other aspects of the birds' natural history (and such mechanisms as the broods' camouflage) serve to influence the chance of a meeting with a predator in the first place. These "direct" and "indirect" defenses interact with each other, and we cannot consider one without the other.

In the competition between prey and predator, each species possesses its adaptations and maladaptations. We realize that what we study of the relations between these animals is the outcome of a long process of selection, but it is also a study of a process that is still taking place. The animals' defenses against killers are probably still being perfected—and so, undoubtedly, are the hunting methods of the predators. It is just one part of the ceaseless struggle for species survival.

SANDY nesting sites in Ravenglass, in contrast to the gulls' customary habitat in marshes, allow predators relatively easy access to the nests.



About the Authors

As director of the National Severe Storms Laboratory, U.S. Weather Bureau, DR. EDWIN KESSLER directs investigations concerning the structure of weather systems and their relation to problems such as air traffic control and storm weather forecasting. He has been with the Laboratory since 1964, before which he was Director of the Atmospheric Physics Division, Atmospheric and Oceanographic Sciences Department, Travelers Research Center, Hartford, Conn. His article, "A Storm's Incalculable Energy," is based on his long involvement in meteorological research and its implications for predicting atmospheric phenomena.

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After a career of many years in industrial chemical research, DR. WINTON PATNODE, author and photographer of "Polarized Beauty," is now a research consultant. He specializes in photomicrography, and he wrote "Green Algae Divide to Multiply," which appeared in NATURAL HISTORY in March, 1965.

DR. B.J. KASTON, author of "Evolution of the Web," has been Professor of Zoology at San Diego State College since 1964. He received his Ph.D. from Yale University in 1934, and has taught at colleges in Georgia, New York, and Connecticut. He has spent more than thirty-three years in research on spiders, and has published numerous scientific papers on their morphology, behavior, and parasitism, and on some aspects of their taxonomy. He is now making life history studies of the black widow.

DR. LUIS AVELEYRA A. DE ANDA, of the Institute of Anthropology of Mexico, and DR. GORDON EKHOLM, Curator of Mexican Archeology at The American Museum, are coauthors of the article on Jaina, an unusual Maya archeological site. Dr. Aveleyra was one of the leaders of an expedition to Jaina in 1964, and Dr. Ekholm has been instrumental in interpreting the significance of the expedition's finds.

"Defense Against Killers," concerning the relationship of Black-headed Gulls to their predators, was written by DR. HANS KRUUK, who is presently in Tanzania engaged in studies on hyenas and other predators. He is of Dutch nationality, a graduate of Utrecht University, and studied for several years with Dr. N. Tinbergen at Oxford University, England. The present article is the outcome of his Oxford project.

TRAVEL / FAR AND NEAR

Rio Grande canoe trip

By Robert W. Schery

About 300 miles southeast of El Paso, Texas, a tortuous half-circle bend of the Rio Grande marks the southern perimeter of Big Bend National Park. The park is outstanding for its rugged beauty, and is particularly remarkable for the three major canyons that the Rio Grande cuts along its 150-mile course from the village of Lajitas, west of the park, to an old suspension footbridge a few miles east of it. A tremendous fault block, on which is superimposed the results of volcanic activity and mountain uplift, has subsided more than 1.000 feet relative to surrounding land where the river courses across the park. At the edges, the Rio Grande cuts through the sedimentary layers of the escarpment making some of the sheerest-walled canyons to be found anywhere today. Particularly in Santa Elena. the westernmost canyon, the river runs between cliffs that rise as high as 1.600 feet.

It was while canoeing this 150-mile stretch that my son, Steve, and I and our two dogs spent one of our more memorable Christmases. But it's not a vacation for the faint of heart, nor for one unwilling to work hard physically. Self-reliance is one of the principal ingredients, but in the remoteness of the Big Bend country, the courtesy of ranger radio communications makes it possible to fit a wilderness outing to a schedule.

How does one get started on this sort of adventure? It may be (as it was with us) that a lad in his late teens reads somewhere that someone surmises it possible to "run" a certain stretch of river in a canoe. It's good winter talk before the fireplace. You mumble something about "Maybe next Christmas."

About Halloween, however, the lady of the house reminds you that this "maybe" has been taken as a promise. "Are you making plans?" she asks. No one you ask has even heard of the canyons, much less canoed this stretch. So off goes an inquiry to the park superintendent. as well as other inquiries in search of a canoe (a good one, but one sufficiently beaten-up so that the loss will not be too stunning if it doesn't get back).

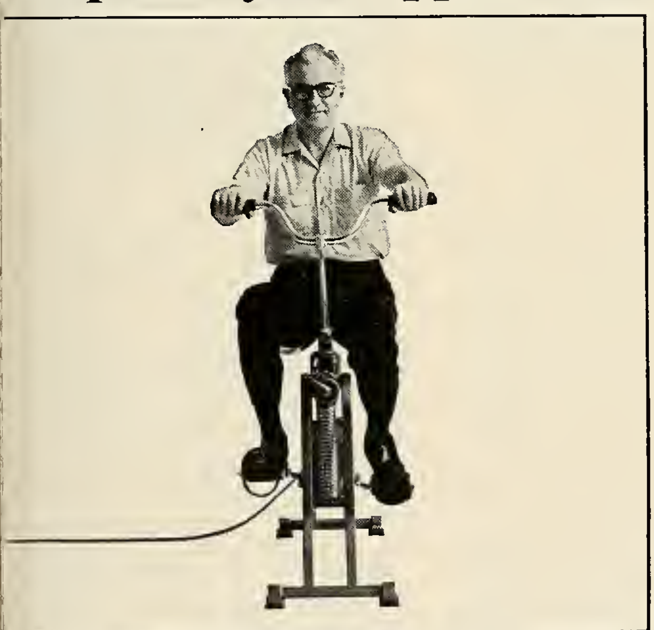
Presently a letter arrived from the park superintendent. "The use of canoes is not recommended." he said. "however their use is not prohibited. We do not know of any place a canoe or other river craft can be rented. . . . To relay your vehicle, it would simplify matters to have your wife do this," and so on.

An enclosed information sheet wa scarcely more encouraging. "The Ri Grande . . . borders the park for 10 miles. . . . It has carved three major can yons which vary in depth from 1,200 t 1,600 feet. The canyons are sheer-walle and, once entered it would be IMPOSSIBL [Park Service capitalization] to get ou of in the event of an accident. In certai locations there is considerable shallov white water or rapids which can be ver dangerous to the novice." The canyon were described separately: regardin Santa Elena—"Seven miles of the canyo are boxed in between sheer walls aver aging 1,500 feet above the river level. A difficult 2-4 hour . . . portage is require around a boulder slide located approxi mately one mile within the canyon."

The information sheet then recom mended a rubber raft for shooting th canyon waters. "Any type of rigid craf is subject to damage from submerge rocks, and there is a danger of breakin up when the boats are slammed into th rock walls of the canyons, due to cross channel rapids. Canoes and similar craf should be used only by the most exper boatmen. as there is danger of capsizin in the shallow, whirling, backlashin currents in some parts of the canyons *We do not recommend the use of canoe for canyon trips.*" (Again, the italics ar those of the Park Service.)

Arriving at the Park

Nevertheless, after much delibera tion my son and I decided to use a aluminum canoe. We picked one up i Missouri on our drive to Texas, and ou party finally arrived at the park's nort entrance. This was the beginning of most gratifying experience with par rangers and their willingness to accon modate us. We told the ranger-in-charg our intentions, and he wrote out a cam ing permit and hauled out a desk-to map. He had only been over parts c this river route himself, and to th best of his knowledge none of the rang ers presently at the park had made th entire swing in a single trip. He didn even know for sure if a canoe had eve made it. He thought it would take si days from the upriver Lajitas embarka tion (to which a passable road runs), t the first possible fetch-out point belo the third canyon (recognized because c an old suspension footbridge). We a gued that four days would be enough fo the 150-mile trip, with any appreciabl


current in the river. He chivalrously conceded, "You know canoes better than I do." but did attach some conditions:

"After the first canyon. Santa Elena, there is a village on the Mexican side with a rowboat 'ferry' that takes Mexicans over to the village of Castolon, about a mile from the river. Would you kindly walk up to Castolon and let the storekeeper know you have gotten this far? A peregrinating ranger stops in each day, and will radio any intelligence about you back to park headquarters. The service will wait an extra day; if you're not out in two days, they'll start looking for you upriver from Castolon. Helicopters can be called in, if it is really thought necessary." With matter-of-fact logic the ranger surmised, "If you get through Santa Elena, we'll presume you can make it. Mariscal and Boquillas are not so tough."

Nevertheless, he recommended that we also check with a ranger outpost some seventy miles downstream just before the beginning of the last canyon, Boquillas. "If you are not there within one day of the schedule you set for yourself, we'll look between Boquillas and Castolon."

Ranger Efficiency

SURPRISINGLY, with these arrangements our trip worked out easily. In one of the least accessible wildernesses in the United States, we were still reasonably in touch with the appropriate authorities. From the Chisos Mountain Lodge, where my wife and daughter spent a few days enjoying the scenery, my son and I were driven at daybreak to the Lajitas embarkation, a distance of about fifty miles. We paddled off immediately, and except for a few minor mishaps in Santa Elena, which slowed down the first lap of the trip, we reported at each check point more or less on time. Late in the morning of the second day we reported to the storekeeper at Castolon, and two days later, seventy-five miles farther downstream, we worked our way up from the river to the Boquillas office. There the ranger radioed our whereabouts to headquarters and relayed the message to my wife to meet us at the footbridge at 6:00 P.M. It was already nearly noon, and twenty-three miles of Boquillas Canyon lay ahead, plus a half-dozen additional miles to the suspension bridge. The ranger argued that we would never make it by nightfall—but he was obviously thinking in terms of rubber rafts!

Sure enough, we first sighted the suspension bridge at about 6:15, later learning that the pickup car had been on the scene for exactly fifteen minutes. On most occasions our family can't meet with this precision on a street corner in Columbus, Ohio; but thanks to the rangers we managed it in western Texas, separated by four days and 150 miles of practically impassable country!

Portage and Swamped Canoes

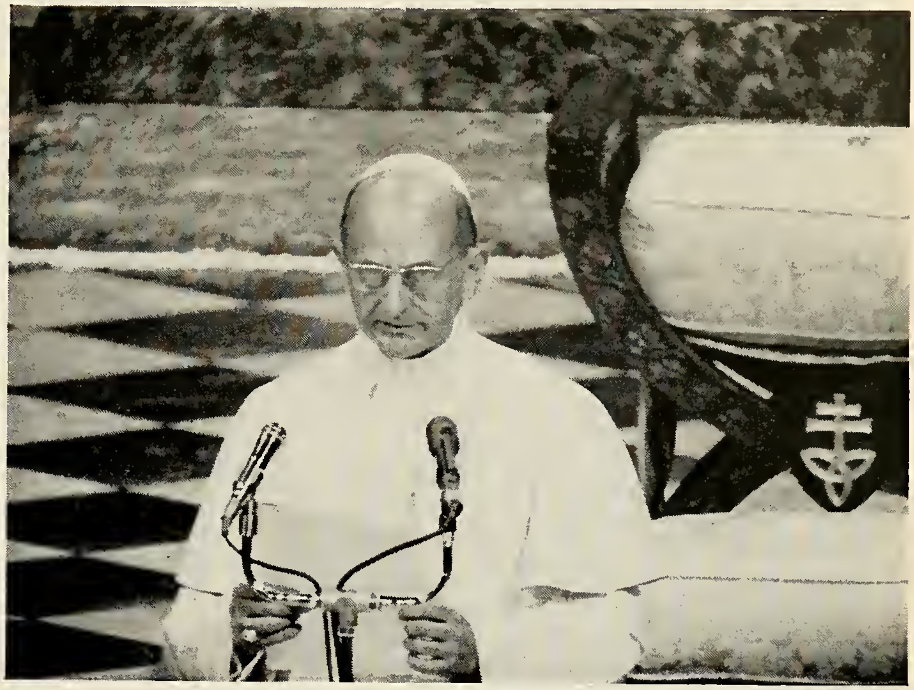
cannot even attempt to describe the canyons and the river scenery of that anoe trip; and no suite in the world's nest hotel can match a night's camping n a Rio Grande sandbank between the reat canyons of the Big Bend—even if ne's duffel is wet. We upset four times ı the course of the trip, although two f the overturns stemmed merely from ot minding our *p*'s and *q*'s.

As the ranger had said, the toughest anyon was Santa Elena. Next time, I vould probably park most of the duffel t the Castolon store and pick it up *after* ve have passed the canyon. It's no fun arrying the duffel over the vaunted rock lide. The boulders are each as big as a ruck, and one man must climb atop nd the other boost from below to get canoe up and over each one. Two hours s not too pessimistic an estimate for this uarter-mile portage. Make it three trips once for the canoe and twice for the uffel—heavy because of wetness), and t can prove exhausting.

This particular stretch was our only eally tough go. In the fast water just bove the slide—into which the river ours, sucking down most anything that loats—we failed to make shore in time vith a loaded canoe, and were swamped.)f course the duffel was lashed in, in upposedly waterproof sacks, but in the ifteen minutes it took to work the water-illed canoe back to shore, the duffel be-ame pretty well slashed in the current, ınfortunately soaking our camera and uining all our film.

Not everyone may want to canoe the Rio Grande, but the rewards of the wil-lerness are certainly worth the effort. Big Bend is a land of many wonders. As he Park Service brochure says, it "is a wild kind of scenery that is more like hat of Mexico, across the river, than hat of the rest of the United States. The lesert is gouged by deep arroyos . . . that expose colored layers of clay and rock . . . rugged mountain ranges, near and far, give assurance that the desert is not end-ess." And from the peaks of the Chisos (which means "enchantment"), one will ind few views more exciting than that southward across the Big Bend into Mex-ico—where it is said that "you can see into the day after tomorrow." Fortu-nately, the newness and remoteness of Big Bend National Park has so far protected it from the heavy pressures that so many national parks now sus-tain. And I surely hope that this remark-able park will be spared too many roads and too many "improvements." To my mind, it—and its rangers—are just right as they are.

Dr. Schery, who is Director of The Lawn Institute in Marysville, Ohio, wrote the Kentucky bluegrass article in Natural History, December, 1965.



SCIENCE IN ACTION

Mold-made flavors

By Lucy Kavaler

Of all cheeses known to mankind, those in which molds are used are the ones that have been most favored by gourmets. In recent years, however, even steak-and-potato eaters have acquired a taste for the tart, unusual flavors imparted to a bland cheese by a mold.

Cheese was one of the earliest manufactured foods, and may have first been made accidently in Arabia about 4,000 years ago. Some 2,000 years were to pass, according to legend, before molds added flavor to some of the cheeses. This development too, we are told, happened by chance. Many centuries ago, a young shepherd took his flocks out to graze on the mountainside near the little village of Roquefort, in France. A sudden downpour forced him to take shelter in a cave. When the rain stopped, he ran out to gather his wandering sheep and forgot his lunch of bread and cheese in the cave. Several weeks later he happened to return to the same place; the bread had crumbled away, and the cheese was run through with veins of a blue-green mold. Still, the boy was hungry, so he took a bite of the discolored cheese and found that it tasted better than any he had ever had before. Unable to explain what had happened, he dashed down to the village, shouting, "A miracle, a miracle." The townspeople gathered round and sampled the boy's discovery. From that day on they began bringing their cheese to the caves around Roquefort so that it could be transformed by the wonderful blue-green mold.

Whether skeptics accept this account at face value, there is indeed something about the caves at Roquefort that makes molds perform "miracles" of growth. A series of cracks and crevices in caves lead both to the top of the mountain and to an underground river. As a result, there is a steady flow of cool, moist air through the caves. The temperature remains a constant 50 degrees Fahrenheit all year round, and the humidity stays at 95 per cent. Cheese—or any foodstuff—left in the caves for any length of time becomes infiltrated by fungi.

By Royal Decree

The mold-ripened Roquefort was quickly adopted by toga-clad gourmets. By the first century A.D., Pliny the Elder reported in his *Natural History* that it was being sold in Rome. Seven centuries later Charlemagne was declaring that it had a flavor fit for the gods. Although no other caves are as perfect for fungal growth as those at Roquefort, molds are ubiquitous, and the originators of the cheese were soon hard pressed to maintain their monopoly. Fearing that inferior versions would destroy their reputation, they applied to the king for help. Royal decree soon restored their position of pre-eminence. Charles VI ruled that the name Roquefort could be applied only to cheese made in the caves near that one town. A century or so later, Francis I repeated the order, and in 1666, the Parliament of Toulouse passed a law to this effect. In 1785, a heavy fine was levied on anyone selling cheese under false pretenses. Even today, a French regulation limits the use of the name. The same kind of cheese, when made in other parts of France, is known collectively as *bleu* cheese.

The mold involved in the making of Roquefort and all the other blue cheeses is one of the most common, *Penicillium*, found with other fungi and bacteria in unpasteurized milk. Whenever it became the dominant mold in a lump of cheese, the now-familiar blue-green veins would work their way through the interior. Cheese makers came to realize that they could guarantee this appearance in a new cheese by inserting scrapings of blue-green mold from an old one. But only in comparatively recent times could mold growth and quality be controlled.

The species of mold that is needed has quite naturally been named *Penicillium roquefortii*. (It is related to the mold that makes penicillin, but has no antibiotic qualities itself.) A pure culture of *Penicillium roquefortii* is made and put on a loaf of fresh bread. The mycelium spreads out through the bread, the spores are formed, and gradually there is less and less bread and more and more mold. At the end of four to six weeks, the bread has crumbled completely and the mold is separated from it. *Penicillium* is then dried into a powder and either sprinkled on the cheese or inserted into it with a needle. The cheese is salted and left for several days, and then at least sixty holes are punched to allow air to reach the mold deep in the interior. *Penicillium* is allowed to grow for a period ranging from two to five months, depending on the market.

Although all blue cheeses contain the same mold, not all are made with the same kind of milk. In the United States and Canada, either cow's or goat's milk

is used, while the true Roquefort and some of the other French blue cheeses come from sheep's milk. A ewe produces only one quart of milk a day, and this for only six months of the year—one reason for the high price of Roquefort.

Herds of 700,000 ewes provide the milk used in Roquefort, where the cheese is still made in twenty-five caves in the nearby mountainside; some of the caves penetrate the mountain as deep as the height of a twelve-story building. During the six months of the year when the sheep give milk, the entire population of the town, about 1,300 people, is involved in cheese manufacturing.

Trial and Error

American efforts to duplicate the flavor of Roquefort were not successful until about 1918, as the French were understandably intractable in their refusal to divulge their secrets. Mycologists had first to identify the fungus and then to calculate how much of it was needed. After that, by trial and error, the temperature and humidity of the French caves were simulated in this country.

Cheese fanciers who are confused by the many varieties offered in specialty food shops and foreign restaurants might bear in mind that many besides Roquefort or blue are brothers-in-mold, with blue-green veins running through them. And many of them did not originate in France. The Italians developed Gorgonzola in A.D. 879, and it helped to make Italy the cheese-making center of Europe in the two centuries that followed. As for the English, their reputation rests securely on Stilton, a cheese that no one else in the world has been able to duplicate successfully. Stilton is a cream-colored cheese, veined with the same *Penicillium roquefortii* that gives flavor to both Roquefort and Gorgonzola. Its taste, however, is milder than either. Handling this cheese is not a task for weaklings, as it is traditionally made into huge cylinders nine inches high, eight inches wide, and fourteen pounds in weight. Versions of blue-veined cheeses are produced in other countries; the Greeks have Kopansiti; the Norwegians inoculate sour skim milk with *Penicillium roquefortii* to make Gammelost, and the Swiss version is Paglia, which is most similar in flavor to Gorgonzola.

Europeans are pained by American insistence on keeping these blue-veined cheeses in the refrigerator. The right thing to do, they maintain, is to wrap the cheese in a damp cloth and put it in the cellar. Exporters, yielding to our national enthusiasm for refrigeration, urge that at least cheese not be frozen.

Whatever the method of storing, none of the blue cheeses is long-lived. The mold goes right on growing even after the cheese has been packaged, and the flavor keeps getting stronger. Cheese

ıakers do their best to plan ahead, and loquefort, for example, is shipped to the Jnited States on the understanding that : will be eaten within sixty days of its rrival. This is sometimes overlooked by eople who have heard how cheeses are ept for decades by peasant families in emote areas. Those are all hard cheeses, owever, like the Swiss Saanen, which ; made at the birth of a child and eaten n his birthday each year.

Napoleon Named It

QUITE another mold-ripened type stands high on the roster of the vorld's great cheeses. This category conists of cheeses like Camembert, in which ıe molds grow only on the surface and o not work their way through to the ıterior in veins. Camembert lacks the vide acceptance accorded Roquefort, ut true cheese lovers consider it to be eyond compare. Its flavor, more subtle ıan that of Roquefort, is produced by nother member of the *Penicillium* famy, *Penicillium camemberti*, together vith bacteria and lesser quantities of ther fungi. The rind of the cheese is overed with a thin, feltlike layer of rayish-white mold with patches of redish yellow. The inside is yellow and unny. The older it is, the more fluid.

This cheese was created in 1791 by Iarie Fontaine, a native of the tiny illage of Camembert. It might have reıained just one of France's many littlenown local cheeses were it not for the ıct that Napoleon Bonaparte chanced › visit this region and was served it. He sked its name and was told that none ad yet been selected. Napoleon then, vith surprising lack of imagination, romptly named it "Camembert," conerring permanent fame on both the heese and the town where it originated.

A similar cheese, Brie, is made in another part of France, and is about as old s Camembert; but it lacks Napoleonic egend to enhance its reputation.

Many other cheeses also owe much of ıeir flavor and odor to organisms growıg on their surfaces. Limburger attracts ıose whom it does not horrify; its odor ; caused mainly by a surface growth of easts and bacteria. People blame and/r praise the Germans for Limburger, ut it was originally made in Belgium.

A Well-kept Secret

STILL milder cheeses are produced when surface molds are allowed to ıultiply for only a short period of time. 'he most popular of these is Bel Paese. 'hich means beautiful country and reers to Italy, its country of origin. The 'rappist monks of the Abbey at Port du alut, France, have kept secret for nearly hundred years the process by which ıey make their famous cheese. Experts, owever, are certain that microorganısms growing on the surface are an es-

MRS. KAVALER, from whose *Mushrooms, Molds, and Miracles* (©The John Day Company) we obtained this excerpt, has written several books on natural history for young people.

sential part of it. As for Neufchâtel, sometimes described as the cream cheese with character, a thin coating of white mold grows on the surface to be followed by a yellow or reddish growth. Mycologists have identified *Penicillium camemberti* among these vitally needed microorganisms. American Neufchâtel is different in flavor from the imported. as the molds are not given time to become fully established before marketing.

Versions of "hand" cheese are found in many countries of the world. The Venezuelans call it "Queso de mano," the Russians "Livlander," the Austrians "Olmützer Quargeln" or "Bierkäse," the Germans "Handkäse" or "Kuhkäse." In America, it is most often made by Pennsylvania farmers of German extraction. As its name suggests, this cheese was originally molded by hand, and in some parts of Europe, it still is. Yeasts, molds, and bacteria all grow on its surface, contributing to the flavor.

To this day "cooked" cheese, sometimes called "cup" cheese or "Pennsylvania pot cheese," remains one of the few kinds still prepared at home, as well as in dairies here and abroad. The method has not changed since its inception. The skim milk curd (leftovers are fine) is ground in a meat grinder and put in a pot where it is kept warm for several days until it ripens. At that point, the top of the curd is covered with a thick, tangled mass of mold mycelium. The curd is then cooked for about half an hour, and stirred constantly. When it reaches the consistency of honey, it is poured into cups and cooled. The finished cheese is similar in texture to Camembert.

The pleasure given by a good mold-ripened cheese is an indication of the dualism of the fungi. The same molds are the nuisance organisms responsible for spoiling the flavors of many foods. In fact, some purists insist that the term "mold-ripened" is a euphemism, and that the correct expression is "rotted."

This list details the photographer, artist, or other source of illustrations, by page.

COVER—Lee Boltin
12-13—T. Mike Fletcher, Black Star
14-17—U.S. Dept. of Commerce, Weather Bureau except 14-15—top and 17—bottom, U.S. Air Force
18-19—Aaron O. Wasserman
20-21—Richard G. Zweifel except 20—top, Aaron O. Wasserman
22—Richard G. Zweifel, except bottom right, Aaron O. Wasserman
23—Robert H. Wright
25—Winton Patnode
26-33—B. J. Kaston except diagrams, AMNH after Kaston
34-35—Marc Riboud
36-38—Helmut Wimmer
39—AMNH
40-47—Lee Boltin except 45-46—Luis Aveleyra A. de Anda
48-55—Hans Kruuk except diagrams, AMNH after Kruuk

Suggested Additional Reading

A STORM'S INCALCULABLE ENERGY

Tornadoes of the United States. S. D. Flora. University of Oklahoma Press, Norman, 1953.

Introduction to Theoretical Meteorology. S. L. Hess. Holt, Rinehart and Winston, Inc., N.Y., 1959.

The Thunderstorm. L. J. Battan. Signet Science Library Series, P2473, New American Library of World Literature, Inc., N.Y., 1964.

IT COULD BE A "FROAD"; MAYBE A "TROG"

Handbook of Frogs and Toads. A. H. Wright. Comstock Publishing Associates, Ithaca, N.Y., 1949.

Amphibians of Western North America. R. C. Stebbins. University of California Press, Berkeley and Los Angeles, 1951.

POLARIZED BEAUTY

Polarization of Light. H. N. Todd. Pioneer Scientific Corporation, Rochester, 1960.

Fundamentals of Optics. F. A. Jenkins and H. E. White. McGraw-Hill Book Co., Inc., N.Y., 1957.

EVOLUTION OF THE WEB

The Evolution of the Webs of Spiders. J. H. Comstock. *Annals of the Entomological Society of America*, Vol. 5, pages 1-10, 1912.

Notes on the Biology of Spiders. I. The Evolution of Spiders' Snares. W. S. Bristowe. *Annals and Magazine of Natural History*, Series X, Vol. 6, pages 334-342, 1930.

American Spiders. W. J. Gertsch. D. Van Nostrand Company, Inc., Toronto, 1949.

CLAY SCULPTURE FROM JAINA

Pre-Columbian Art. Robert Woods Bliss Collection. S. K. Lothrop. Phaidon Publishers, Inc., N.Y., 1957.

Mayan Terracottas. I. Groth-Kimball. Praeger. N.Y., 1961.

The Ancient Maya. S. G. Morley and G. W. Brainerd. Stanford University Press, Stanford, Calif., 1956.

DEFENSE AGAINST KILLERS

Predators and Anti-Predator Behaviour of the Black-Headed Gull (Larus ridibundus L.). H. Kruuk. *Behaviour*, Supplement XI, 1964.

On the Functions of Territory in Gulls. N. Tinbergen. *The Ibis*, Vol. 98, pages 401-411, 1956.

The Nature of the Predator-Reactions of Breeding Birds. K. E. L. Simmons. *Behaviour*, Vol. 4, pages 161-171, 1952.

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ARTICLES

DEPARTMENTS

COVER: This male frigate-bird, which is somewhat impeded by its wobbling gular sac, is flying from one display site to another. There it will alight, fully inflate the sac, throw back its head, and "warble" to attract a female that might be flying overhead. The frigate-bird, a member of the same order as tropic-birds, pelicans, gannets, boobies, cormorants, and anhingas, has many strange behavior patterns. These are discussed on pages 32 to 39 by Dr. Bryan Nelson who, with his wife, studied the birds on Tower Island in the Galápagos. The cover photo was taken by Karl Kenyon, and all those that illustrate the text by Dr. Nelson.

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BOOKS IN REVIEW

The meaning of science

By Jane Oppenheimer

THE SCIENTIFIC REVOLUTION, by W. E. Knowles Middleton. *Schenkman Publishing Co., $2.65; 88 pp., illus.* THE CHALLENGE OF SCIENCE, by George Boas. *University of Washington Press, $2.95; 92 pp.* THE IDENTITY OF MAN, by J. Bronowski. *The Natural History Press, $3.95; 107 pp.*

SCIENCE means knowledge—*scire* is to know—and since man became man, knowing has been his most important and characteristic activity. One of the more interesting aspects of science in the mid-twentieth century is that it tries to acquire knowledge not only of nature but also of itself as an inquiry into nature. Science today is thus a highly self-conscious discipline. Scientists, as well as some of the ablest minds of philosophy, address themselves to the problems of what science is, of what it means to man, and of what man means to himself in the light of scientific and other-than-scientific knowledge.

These are popular subjects for lectures, and series of lectures have ways of transforming themselves into books; the three small books under review here all had such beginnings. W. E. Knowles Middleton's *The Scientific Revolution* is based on a series of lectures delivered over the Trans-Canada Network of the Canadian Broadcasting System; George Boas' *The Challenge of Science* reproduces three John Danz lectures delivered at the University of Washington; and the essays by J. Bronowski on *The Identity of Man* were presented at The American Museum of Natural History to inaugurate its new series of lectures on "Man and Nature."

Some scientists find that looking at science historically helps them formulate what science is and how it operates. Middleton is a physical scientist of distinction who has specialized in optics, and who in his retirement is devoting himself to the history of science. His book, rather unconventionally, unevenly, and unattractively printed, attempts, in its own words, "to provide a concise account of the development of man's view of the physical world from the earliest times up to about the year 1700." Covering this much physical science in 81 pages permits little opportunity for either depth or originality. The account is straightforward and simply presented, but while the lectures may have been successful, their publication does not add greatly to the sum of human knowledge.

The Challenge of Science is also unconventionally printed with respect to typography, but its pages are exceptionally beautiful. The Danz lectures are delivered by scholars concerned with the impact of science and philosophy on man's perception of a rational universe. Boas is a historical philosopher with a particular interest in esthetics. His lectures discuss in turn the challenge of science to the arts, to philosophy, and to religion. He sees science as experience, and he questions how the scientific experience differs from and resembles the artistic, the philosophical, and the religious experience. But he goes further than this. He says in his introduction: "It would make no sense to ask a scientist, 'What is your physics or chemistry or biology?' but it does make sense to ask a philosopher, 'What is your philosophy?' " His own philosophy includes the recognition that there are esthetic and intuitive elements in science; yet these elements are for him only two of many factors influencing the impact of science on art, philosophy, and religion.

The word philosophy sometimes has a different connotation to the layman and to the professional. When the former asks, "What is your philosophy of life?" the latter tends to frown at the form of the question, to ignore its last two words, and to couch his reply in both jargon and concepts formulated on a plane above the reach of the inquirer. Not so Boas; his lectures are written in the framework of life as it is lived, of science as it is experienced, of art as it is created, of religion as it is believed in, in the year 1965. His imaginative discussion of the meaning of science in 1965 will be lucid to readers at all levels who care to think about science and the thoughts, creations, and beliefs of man in their broadest relationships.

The Challenge of Science is discursive rather than expository, and wonderfully written. So also is Bronowski's *The Identity of Man*. Bronowski, Deputy Director of the Salk Institute for Biological Studies, like Boas, constructs a philosophy for modern man; like Boas he lives by the belief that "the act of discovery in science engages the imagination . . . as truly as does the act of creation in the arts," but he develops his thesis differently from Boas. The latter, in discussing the nature of experience, points to its private quality. But where Boas looks upon private experience somewhat from without, as becomes a philosopher, Bronowski looks more deeply into the privately experiencing self. In one essay he

describes science as an account of the machinery of nature in linguistic terms; in another, he probes the acquisition of nature through art, specifically through literature, more specifically through drama and poetry. He concludes that "the identity of man derives from the coming together of two modes of experience, and is fixed in two modes of knowledge: knowledge of the physical world, and knowledge of the self."

"What is man," asks the Psalmist, "that Thou art mindful of him?" Bronowski helps us to know what is man, and with Boas, helps us to understand him in a world for which the Psalmist, as well as the scientist, is a spokesman.

Dr. Oppenheimer, Professor of Biology at Bryn Mawr College, is interested in embryology and the history of science.

FAIR ISLE AND ITS BIRDS, by Kenneth Williamson. *Oliver and Boyd (Edinburgh), 30s.; 311 pp., illus.*

THIS is an enjoyable, largely non-narrative account of Fair Isle, the remotest inhabited British island—its people, history, and birds—written in clear, extroverted style with many fine descriptions, although some of the "human touches" made me squirm a little. Immature Arctic jaegers are described as being in the "Youth Club . . . interested only in having a gay time," and "we were *shocked* to find that Arctic skuas have . . . divorces just like human beings."

The book has real meat, although it avoids detailed analysis. Most of the material has appeared elsewhere, but it is good to find it gathered between two covers. The lucid exposition of weather and its relationship to migration, coupled with evocative writing about the birds, lends immediacy to the account; I felt as exhausted as the Wheatears after their 1,500 mile trip from Greenland to Fair Isle, round the rim of a depression. Williamson has long worked like a beaver at his version of migration "drift" (which involves flying downwind, not suffering mere lateral displacement from a preferred course). In this book he gives so much supporting evidence for his thesis that he should have discussed the alternative interpretation.

His treatment of bird behavior is weaker; it lacks clear formulation on general topics (displacement reactions, substitution activities, ritualization), and confuses causation and function. Strangely, he fails to acknowledge Lorenz, Tinbergen, or any other ethologists who were largely responsible for these concepts. Although it was good policy to omit a detailed bibliography, he does make appropriate blanket references on other topics—why not on behavior?

The sketches are adequate, but I do

not quite understand why so many general photographs of Fair Isle were included, while there were so few (and those ordinary) of the birds. Still, this is a good buy, containing a stimulating and well-mixed collection of information.

BRYAN NELSON
Aberdeen University

THE NATURAL HISTORY OF FLIES, by Harold Oldroyd. *W. W. Norton & Co., $8.50; 324 pp., illus.*

A tremendous amount of data on Diptera is to be found in the scientific literature, and although several excellent general accounts on the biology of these insects have been published, none has been available in the English language. Oldroyd's survey of the natural history of the group fills this gap, and also has a highly original approach. His theme is "the evolution of flies, using their natural history to show how each group represents a stage in the more efficient exploitation of natural resources."

The two main evolutionary lines in the Diptera are the Nematocera (midges, true mosquitoes, and their allies) and the Brachycera (or flies proper). Perhaps nothing better characterizes Oldroyd's style and observational sensitivity than his remark on the Brachycera as opposed to the Nematocera: "Though some of them are quite small, they lack the fragility of the midges. Even the slender ones have bulk, and in a curious way, individuality. If we see one midge, or even one mosquito, we instinctively look for others; but one fly goes about its business in a seemingly purposeful way, and is self-sufficient."

General remarks on the Diptera, their over-all classification and life history, are followed by the main portion of the book, which I would like to call a comparative biology of the families of Diptera. Oldroyd demonstrates how the various taxa, either individually or in groups, show different levels of structural and biological organization, and are adapted to different and progressively more specialized ecological niches. The author's data are derived from extensive sources and supported by a carefully done bibliography.

The last, and especially fascinating, chapter is called "The Past, Present and Future of the Flies." Recently successful flies—those with a large number of taxa and wide distribution—are contrasted with those declining or on the way to extinction (in the evolutionary sense), characterized by possessing a reduced number of genera and species, and often a limited geographical distribution.

Oldroyd also stresses the role man plays in determining the future of flies. The Tabanidae, or horse flies, furnish a good example. This is a family with hundreds of species; the adults of some attack man and domestic animals, but the vast majority feeds on the blood of wild animals. These flies are now being affected to a large degree by drainage of land, which destroys the sites where the aquatic larvae live. Large-scale game destruction, which eliminates the food sources of the adult tabanids, contributes to a possibly dark future for many of the species of this family. More direct measures, such as the often indiscriminate application of insecticides and other control activities, will also have consequences. Oldroyd speaks for all biologists when he states that "we have discovered organic evolution just at the time when our own activities are putting a stop to it in many directions, or at least violently altering its course."

The book is beautifully printed. The drawings, most of them done specially for this work by the excellent entomological illustrator Arthur Smith, are well chosen, technically perfect, and flawlessly reproduced. The reader not well acquainted with the Diptera will be especially grateful for the generally good and sometimes dramatic photographic illustrations. Considering the apparent excellence of the original photographs, however, one could wish for better reproduction quality.

The Natural History of Flies is full of facts and ideas presented in a lively and interesting style; I recommend it highly. Although probably written for the non-specialist, it will hold the attention of almost any entomologist who has not lost the sense of wonder before the manifold variety of life.

PEDRO WYGODZINSKY
The American Museum

THE QUEST FOR SUMER, by Leonard Cottrell. *G. P. Putnam's Sons, $4.95; 222 pp., illus.*

THERE has long been an opportunity for the writing of a short, accurate, and exciting book introducing students and the layman to the history of archeology in southern Mesopotamia, the home of the ancient Sumerians. Since the middle of the last century, this land (which was called Sumer, not Sumeria!) has been the object of many expeditions. Their history includes both exciting adventures and the thrill of discovery as new finds unrolled the story of these ancient people. The record of how an understanding of the significance of their remains developed challenges the intellect and poses unsolved problems for further consideration.

The author unfolds his tale in a proper chronological order, but the book lacks the warm understanding and personal involvement that made Cottrell's earlier books entertaining reading. Clearly (as he himself says) his heart belongs to Egypt. The chapters dealing with the

recapitulation of the Ur expedition and some of the features of Sumerian life are acceptable enough; not so, alas, the chapters dealing with early prehistory and the flood story, which are sadly out of date. Even more discouraging, the volume is filled with inaccuracies caused by bad editing, in addition to factual error. The reader must be cautioned, therefore, not to accept any statement without reference to an authoritative source. The idea of the book was a good one; unfortunately, its execution is not an acceptable treatment of the subject.

ROBERT DYSON
The University Museum

LIFE ON THE SEA-SHORE, by A. J. Southward. *Harvard University Press, $3.00; 153 pp., illus.*

DR. SOUTHWARD is eminently qualified to write about life at the seashore. For many years his specialized research activities have been in the intertidal zone, which is defined as the "lowest level uncovered by the tides to the point washed or splashed by the waves at the highest tide."

The intertidal zone is rigorous and exacting. In this environment, which is actually a composite of environmental conditions, organisms must have biological properties that periodically permit them to lead double lives—one in the sea and one on land. Adaptation to one environment is difficult, to two it is biological "featsmanship." Yet, in these few feet of ocean a stunning variety of animals and plants (algae) have evolved with the needed prerequisites.

The book is organized into several sections. The first—and largest one—is concerned with three major types of intertidal zones: the rocky shore, the sandy beach, and the mud flats, plus estuaries and lagoons that have their own special properties. Each zone contains characteristic species, and each species has its limitations of spread, determined by biological factors, within a zone. Species of each zone are described generally, their upper and lower limits between the tides are given, and they are illustrated with zonal charts and drawings, plus photographs.

In the second section, Dr. Southward discusses the biological adaptations to this double life, and the causes of zonation are clearly explained. Biological tolerance to temperature, desiccation, submersion, wave action, and tidal movement, for example, dictates the extent and the range of the animals and plants within the zones. Mode of reproduction and development are also important in intertidal distribution, in addition to conditions of crowding and compatibility with neighboring species. The section includes new findings, such as the work on aerial respiration in barnacles.

The third section is devoted to some quantitative methods of analyzing the sea and the ways in which life at the seashore can be studied. Scattered throughout the book. too. are relatively simple experiments that the amateur marine ecologist can carry out.

It is a small book that can easily be carried by an intrepid explorer with damp sneakers. It is well sprinkled with quantitative data. and the writing is tight. Its information is highly concentrated and nourishing. like dehydrated soup. The intertidal zone is one of the best training grounds for aspiring zoologists. although Dr. Southward points out that the reader must have some knowledge of invertebrate groups before embarking on a study of the seashore.

Unfortunately. the printing job leaves something to be desired. and the charts showing the distribution of the animals and plants are sketchy. although the other diagrams in the book have a much better and more definitive quality. The glossary is fair, the index adequate, and the suggestions for further reading incorporate many original research papers.

One point that should be mentioned is that the book is written about the British coast. but fortunately. animals and plants are not chauvinistic. and Britain's floral and faunal distribution is comparable to many areas throughout the world.

I recommend the book as an introduction to life at the seashore.

EVELYN SHAW
The American Museum

AJANTA. by Madanjeet Singh. *The Macmillan Co., $19.95: 189 pp.. illus.*

THIS is the first comprehensive work on the Ajanta paintings to appear in the American press. These Buddhist cave paintings. the oldest in the world. range in date from the second century B.C. until the seventh century A.D. Painted by Indian Buddhist monks, the Ajanta murals represent prototypes of all later Buddhist art in Asia. This book will probably become the definitive treatment of the exquisite paintings in terms of skill of organization and clarity of presentation for large audiences. Mr. Singh's sensitive exposition is interspersed with summaries of Jataka stories —parables told by the Buddha to illustrate points of theology. These add immeasurably to the Westerner's understanding of individual murals. The last section of the book is devoted to a detailed description of seventeen of the caves. and ties the vast panorama of the murals into a meaningful whole.

Since the soft. luminous quality of many of the Ajanta paintings is almost impossible to capture with a camera, the illustrations are about as good as one can expect. Some, however, appear to have been retouched. A plate showing the Bodhisattva Padmapani of Cave 1, perhaps the masterpiece of all Ajanta, has retained little of the mysterious luster it provides the viewer on the site. While Mr. Singh extols the beauty of the Ajanta women in the paintings. some of the loveliest have not been included.

This book is a distinguished achievement. The author skillfully links the context of the murals to the contemporary scene of the time in which they were painted. What seemed underplayed was the individual Buddhist artist-monk's religious intent in his works. Mr. Singh instead stresses the nuances of art styling and the delineation of transitional art forms. However. the entire work makes a book of rare beauty that is a major contribution to the history of Asian art.

ROBERT S. MCCULLY
Cornell University Medical College

DEITIES AND DOLPHINS, by Nelson Glueck. *Farrar, Straus and Co., $15.00; 650 pp., illus.*

THIS handsome book is about a talented people who should be better known, for they have bequeathed to us some of the world's most beautiful remains, including Petra. Dr. Glueck has devoted over thirty years to the study, exploration. and excavation of Nabataean sites. Although his excavations at Khirbet Tannur and his archeological surveys of hundreds of other sites are central in the discussion, the book delves into Nabataean history, art, religion, and foreign connections.

From around 200 B.C. to A.D. 200, a number of caravan cities and city-states flourished in the Near East. One of them was the Nabataean kingdom whose capital was Petra. The realm grew rich by providing security in exchange for the tolls paid by the caravans. It was well located for taking advantage of the trade routes from south Arabia to the Mediterranean, and from Egypt to Jerash and Damascus. Rome cast covetous eyes on the caravan cities and vanquished them one by one.

The Nabataeans were Arabs who wrote in Aramaic. and who had absorbed much Greco-Roman culture. They borrowed creatively. for their buildings. carved out of the purple mountains at sites like Petra. are adorned with Greco-Roman façades of indescribable beauty. The Nabataean achievement is distinctive and not merely imitative.

Dr. Glueck has been able to identify a large number of Nabataean mounds by the characteristic potsherds that lie upon their surface. Nabataean pottery is thin and delicate; it is usually light reddish brown in color and is often decorated with black and dark-red geometric patterns. Once anyone becomes familiar with it, he will always be able to recog-

ze it without difficulty. It was through e testimony of the surface sherds that lueck discovered hundreds of abanoned Nabataean settlements.

This book will open new vistas for any readers and impel some of them to iclude Petra in their itineraries when ley travel to the Near East. Petra is now ccessible, and is equipped with a guestouse adjacent to the "Castle of Phaaoh's Daughter" in the midst of the iins. The Arabs call Petra "Wadi lusa" (The Valley of Moses), and connect the landscape and buildings with arious details of the stories about the anderings of Moses and the children f Israel. Accordingly the names of varius spots in Petra refer to Moses, Aaron, haraoh, and Pharaoh's Daughter.

Deities and Dolphins is the work of a easoned authority on an interesting opic. It is recommended to scholar and ayman alike as the book par excellence n the Nabataeans.

Cyrus H. Gordon
Brandeis University

'he Medes and Persians, by William lulican. *Frederick A. Praeger, $7.50; 60 pp., illus.*

The "Ancient Peoples and Places" series, of which this is volume fortywo, is composed of concise surveys of arly nations and cultures. Professor Culican's book, *The Medes and Persians*, s in the high standard of authority and eadability set by the series, and is to e strongly recommended.

The author, a professor in Semitics at the University of Melbourne, achieves a nice balance between sweeping summary and factual detail. His suggestions and conclusions in thorny areas where few scholars agree are prudent. His story concerns the cultural history of the two Iranian peoples whose confederation produced the fabulous Persian Empire that ruled most of the then-known world in the sixth and fifth centuries B.C. The Bible shows the Persian kings in a relatively friendly light, but every schoolboy is thrilled by the heroic deeds of a handful of Greeks as they checked and finally defeated the hordes of Oriental barbarians under Darius and Xerxes at Marathon, Thermopylae, and Salamis. This book shows that behind the avaricious, despotic façade described by the classical writers, the Persians were a cultured, sophisticated, politically astute, and surprisingly tolerant people who preferred negotiating over goldladen dinner tables to war on the battlefield. It is also true that they had their full share of court intrigue, fratricidal cupidity, treachery, and stupidity.

The beginnings of the Medes and Persians in the dim years early in the first millennium B.C. can only be vaguely sketched. The literary records in which

they are first mentioned are tantalizingly meager; archeological excavations over the past few decades are slowly filling out the picture. Hence, the art and architecture uncovered by the spade are of capital importance in our rediscovery of these ancient peoples.

The Medes are still, in the main, an unknown quantity, although the author makes a convincing effort to isolate their culture before they were absorbed into the Empire. Unfortunately, we do not have at present a single work that we can identify without hesitation as Median. But there is an excellent chance that archeologists digging in Iran today may correct that situation. For the later history of the Medes and Persians there is rich and spectacular evidence in architecture, sculpture, textiles, and metalwork. The fine illustrations in this volume picture the luxurious refinement of the royal Persian courts before their death knell was tolled by another empire builder, Alexander the Great.

BERNARD GOLDMAN
Wayne State University

THE MAMMALS, by Desmond Morris. *Harper and Row, $12.95; 448 pp., illus.*

THE past few years have seen a relative wealth of works on the world's mammals. The approaches, as well as the degrees of completeness and complexity, have been varied. *The Mammals,* as the subtitle *A Guide to the Living Species* suggests, is an adequate guide to the species, but it is by no means complete. Of the four thousand odd species of mammals, three hundred are covered by some twenty lines of text and a photograph of each. The text for those included is concise, readable, and accurate. There is a good introductory section on the nature and evolution of mammals and some useful tables, maps, and charts that give the orders of mammals, the number of genera and species of each, and the distribution of the orders. As an introductory guide, these portions of the book are worth while.

For all but two of the nineteen orders of mammals, the author has prepared lists of the species, including the scientific name, distribution, common name, and references from which he obtained the information. These lists are of use mainly to the specialist in mammals, but by omitting the bats and rodents, the two orders that contain 62 per cent of all mammals, Morris has greatly reduced the utility of his work.

Priced at slightly more than half the cost of Walker's *Mammals of the World* (NATURAL HISTORY, April, 1965), and containing one-third the number of pages, this book is comparatively expensive for an introductory work.

RICHARD G. VAN GELDER
The American Museum

Some shorts of interest

By Linda S. Gordon

AMONG the many scientific motion-picture films that have been produced . recent years, the following can be ·commended both for educational and itertainment purposes. In general they ·e short, and they are especially useful hen accompanied by science lectures · general interest programs.

The Colorful Cuttle is one of the best lms on cephalopods available for the ıblic. It begins with a brief introducon to the cuttlefish, *Sepia officinalis*, which is related to the octopus and ıuid) and continues with a study of its et propulsion" swimming mechanism. ıots from underneath the animal illusate how a specialized structure can be ırned in any direction to give the cuttleşh precise and rapid steering; similar ews show how the same structure is sed to excavate the hole in which the ıttlefish lives.

The next section of the film is devoted · various changes that take place when ıromatophores expand and contract, ıusing waves of color to pass rapidly 'er the surface of the animal.

The final sequence shows the animal's ›ility to produce the "ink" that acts as decoy or a "smoke screen." The anial's ink sac, by the way, is the source the pigment sepia.

This fourteen-minute, color sound film as produced by Plymouth Films, Ltd., co-operation with the Marine Biologiıl Association of Plymouth, England. It distributed by the International Film ureau, 332 South Michigan Avenue, hicago, Ill. 60604, and may be bought ›r $120.00 or rented for $6.00.

The Octopus, produced by Germany's ıstitut fur den Wissenschaftlichen, is ıother unusual film on cephalopods. It a five-minute, black-and-white silent—ne of a growing collection of internaonal scientific films at Pennsylvania tate University, established with the aid f a National Science Foundation grant.

The film is divided into five parts, the rst illustrating the general motor activies of the octopus, including respiratory ıovements, probing by tentacles, walkıg along the bottom, and swimming. 'he second portion portrays the concenration and dispersion of pigment. Someımes the octopus may be nearly white; t other times it can be marbled or alıost black.

The rest of the film shows the octoıus capturing and eating a spider crab, rranging rocks and shells in front of its ave, and mating. *The Octopus*, as well s other films in the international collection, is available on loan for educational and research use from the Pennsylvania State University Audio Visual Aids Library, University Park, Pa. This particular film may be borrowed for $2.20. Others depict single types of behavior among different species of animals or plants; still others are ethnological, and compare various tribal cultures.

How Pine Trees Reproduce is an eleven-minute motion picture in color or black and white. Produced by Dr. William M. Harlow, Professor of Wood Technology at the State University College of Forestry, Syracuse University, it shows the life history of a pine cone from the floral stage to maturity, and deals particularly with the effect of fire on pine reproduction.

It is a widely accepted idea that in jack pine, lodgepole pine, and knob-cone pine, fire induces the closed cones to open. This, it was thought, produces a large number of seeds at once; these develop into dense, pure stands of young trees on the burned-over area. Recently, however, it has been discovered that fire does not open the cones directly, but only begins the process. In most forest fires the flames race through the tops of the trees, burn off the needles, ignite the resin on the cones, and then subside. About half an hour later the cones open slowly, releasing the seeds, which fall on the cooling ground. Time-lapse photography and photomicrography show the action of the opening and closing cone scales.

This film, recommended for high school students, is a winner of a Cine Golden Eagle Award (1964) and a certificate at the American Film Festival (1964). It is distributed by Encyclopaedia Britannica Films, 1150 Wilmette Avenue, Wilmette, Ill. 60091. The purchase price is approximately $120.00 in color and $60.00 in black and white; rental is $5.00 in color and $3.00 in black and white.

Fish, Moon, and Tides—The Grunion Story has been selected by the Council on International Nontheatrical Events to represent the United States in foreign film festivals. Also a Golden Eagle award-winning film, it was produced by James A. Larsen. Dr. Boyd W. Walker, Professor of Zoology at the University of California, served as science consultant.

The grunion, *Leuresthes tenuis*, is one of the few fishes that spawn on land. Thousands of these silvery, five- to six-inch-long fish come out of the ocean between March and August to lay their eggs on sandy beaches along the Pacific coast from central California to Baja

Mrs. Gordon wrote this column while with the Smithsonian Institution's Museum Service, where she regularly viewed large numbers of science films.

California in Mexico. However, this spawning occurs only on three or four nights at each new moon and full moon as high tides occur, and within one to three hours after the highest tides. The fertilized eggs develop in the sand, and wash out to sea in the next spring tide.

Animated drawings show how spawning is related to tides and the moon, and laboratory shots under a microscope show the development of fertilized grunion eggs. Heartbeats, circulation of the blood, and movements of the living embryo are also depicted. Agitated grunion eggs hatch so quickly that if special attention were not drawn to it the process might be missed by the viewer—even though it has been photographed in slow motion. The film rents for $7.90 or sells for $150.00 from Academy Films, 748 N. Seward Street, Hollywood, Calif. 90038.

The Silent Spring of Rachel Carson, filmed by C.B.S., examines some of the controversy excited by Miss Carson's book, *The Silent Spring*. Is man unknowingly killing himself? Is the "balance" of nature being permanently upset? Miss Carson claimed that "we have put poisonous and biologically potent chemicals into the hands of persons largely or wholly ignorant of their potentialities for harm." She further contended that "These chemicals are used with little or no advance investigation of their effect on soil, water, wildlife, and man himself."

Critics of her theory have charged that Miss Carson grossly distorted the facts and that her accusations were unsupported by experimental evidence and experience in the field. In this forty-four minute film, narrated by Eric Sevareid, experts with different viewpoints were interviewed. They included Dr. Luther Terry, U.S. Surgeon General; Orville Freeman, U.S. Secretary of Agriculture; and Dr. Robert White-Stevens, Assistant to the Director of Research, American Cyanamid Company. For the most part, however, Miss Carson's questions remained unanswered.

Although this black-and-white film could hardly be considered a technical masterpiece, its thought-provoking contents should stimulate discussion and debate from most audiences. It would be a fine choice for an audience participation program. It may be rented for $25.00 or purchased for $250.00 from Contemporary Films, Inc., 267 West 25th Street, New York, N.Y. 10001.

Of all the United States motion pictures shown at the 18th Annual Congress of the International Scientific Film Association, held in Athens in 1964, three from the "Plant Science Film Studies" series stimulated the greatest discussion

These approximately $2\frac{1}{2}$-minute, single-topic film subjects, which were awarded Diplomas of Honor, were produced at Iowa State University under a grant from the National Science Foundation:

Gamete Transfer in the Bryophytes—the Splash Platform in Marchantia gives an example of a structural modification—the so-called splash platform—which facilitates gamete transfer in the life cycle of the liverwort, *Marchantia.*

Liberation of Zoospores in the Alga Basicladia shows the method of asexual reproduction in green algae by the formation of zoospores. The fresh-water alga *Basicladia* seen in this film is often found on the backs of turtles or on snail shells. As zoospores mature, the individual cells in the filament can be observed to darken gradually. An exit pore forms and the spores escape through it during the first few seconds after the pore membrane bursts. After leaving the sporangium, some of the zoospores find a suitable substrate, attach themselves to it, and develop into new filaments.

Algal Syngamy—Oögamy in Oedogonium deals with the sexual reproduction in another filamentous green alga, in this case, the fusion of a large non-motile egg and a smaller motile sperm. Gametic fusion occurs when the sperm passes through the pore in the oögonial wall and unites with the egg. The resultant zygote is then seen to develop a thick wall before germinating.

The above films, in color only, are especially suitable for high school or college classroom use, and are available in 16 mm. with optical sound, 8 mm. with magnetic strip sound, or 8 mm. cartridged silent. Commercial distributors include the Ealing Corporation, 2225 Massachusetts Avenue, Cambridge, Mass., and Modern Learning Aids, 3 East 54th Street, New York, N.Y. 10022. The current price is $15.00 per cartridge. Rental of the 16 mm. sound prints is handled by the Visual Instruction Service, Iowa State University, 121 Pearson Hall, Ames, Iowa 50010. Rental price is $1.50 for a single film, $2.00 for two films, or $3.75 for three films.

Namboodiri Brahmans of Kerala

A unique culture now faces drastic change

By Joan Mencher

"His person is holy; his directions are commands; his movements are a procession; his meal is nectar; he is the holiest of human beings; he is the representative of God on earth." This description of a Namboodiri Brahman of Kerala is in an official nineteenth-century document of Travancore.

THE Malayalam-speaking state of Kerala, in the extreme southwest part of India, is covered with foliage so rich and dense that, at least superficially, it looks like a lush South Sea island. From north to south the state falls into three natural divisions: a narrow coastal strip of sandy beaches and beautiful coconut groves, punctuated by many inlets and inland waterways; a middle area of undulating countryside, with long, winding, paddy fields surrounded by hills covered with thick vegetation; an inland region of highlands, formerly the home of tribal groups and now largely given over to the cultivation of tea in the south and coffee in the north. The physical features of the countryside have never encouraged the formation of compact dwelling areas, so the unit of rural settlement is a single dwelling, rather than a village as in the rest of India.

Kerala has also differed from the rest of the country in its traditional social organization. To both specialist and layman, one of the most interesting characteristics of Indian social life is the caste system. The term "caste" refers to a group in which membership is determined by birth, and which is hierarchically graded with respect to other such groups. This places restrictions on eating with members of other castes and on intermarriage (normally a person must marry within his own caste, although in some cases women are allowed to marry into a higher caste), and under certain conditions caste members consider themselves to be "polluted" by direct or indirect contact with members of lower castes.

The system has been more highly structured and more rigidly enforced in Kerala than in any other part of India. The dispersed houses, surrounded by their large compounds, have made it relatively easy for high-caste Malayalees (Malayalam-speaking inhabitants of Kerala) to maintain their rules of pollution. Today the entire society is in a state of transition.

Among the Kerala castes, the Namboodiri Brahmans ranked highest in religious and in economic and political life. The houses of the Namboodiris, known as *illams*, were surrounded by spacious gardens. Most were palatial structures built of laterite and cemented with mud or mortar. Traditionally, the Namboodiri aristocrats were self-sufficient in their *illams;* they were cared for by servants who paid homage to them in every possible way, and their fields were farmed by tenants who provided rice and other necessities of life.

One of the most striking features of the Namboodiris was their relationship with several of the high castes of Kerala, particularly the Nayars. In a Namboodiri family, only the eldest son was allowed to marry in his own caste (although it was permissible for him to take more than one wife). The family property was never divided, and this custom maintained the economic position and social prestige of the family.

The younger sons, according to tradition, had no property of their own and were expected to remain celibate and devote their lives to religion. However, even records from the Middle Ages indicate that it was customary for them to form marital liaisons with women from Nayar subcastes or other, smaller, high non-Brahman castes. (The Nayars constituted about 18 per cent of the population of Kerala, according to the last caste census, made in 1931.) The Nayars, as well as the other small caste groups who took Namboodiri younger sons as mates for their women, were matrilocal: that is, a woman remained in her natal home after marriage and raised her children there, living under the authority of an uncle or an elder brother. Among these castes, it was customary for a man to spend most of his life in his own home and visit his wife only at night. The matrilocal groups were also matrilineal, with inheritance of property through the female line. The Namboodiris, on the other hand, were patrilocal (a married couple and their children lived in the husband's ancestral home) and patrilineal (inheritance passed from father to son).

TRADITIONALLY, there were two kinds of marriage among the Nayars, the *tali kettu kalyanam* and the *sambandham.* The *tali kettu kalyanam*, or *tali*-tying ceremony, could be held at any time before a girl reached puberty. The *tali* (a gilded, leaf-shaped pendant on a chain) was tied around a

Scattered settlements are typical of the Kerala landscape, where the single dwelling unit, rather than the village, is the custom. This pattern, based on physical features of the land, has helped mold a unique social organization.

Two Namboodiri women, at left, are accompanied on their way to temple by a Nayar maidservant. Palm leaf umbrellas protect against both rain and sun, and they also help in preserving a type of purdah typical of this community.

Moslem and low-caste women harvesting rice on an estate in north Malabar. Although most of the Namboodiri wealth came traditionally from the land, owners still leave most of the agricultural arrangements to their tenant farmers.

The state of Kerala occupies most of the coast of extreme southwest India.

girl's neck either by a member of a family of similar rank or by someone in a higher subcaste.

There have been several interpretations of this rite. Some scholars have suggested that at an earlier period it actually constituted a formal marriage; others, that it represented a kind of coming-of-age ceremony. On the other hand, a French anthropologist, Louis Dumont, has suggested that it was a local adaptation of a customary South Indian rite, because the *tali* is the symbol of marriage in all patrilineal groups in that area.

In any case, following the *tali* ceremony, and after a girl's first menstruation, she formed what is called a *sambandham* union (the customary nuptials of a man and woman) with a man of her own subcaste or a higher one. Since property was inherited through the Nayar female line, ther[e] was no need for her *sambandham* ma[te] to care for her or their children.

There has been considerable contro[-] versy in the Indian courts as to whethe[r] such a union constituted a marriag[e]. However, it is clear that the Nayars[—] but not the Namboodiris—so viewe[d] them. From the Namboodiri point o[f] view, such unions with Nayars wer[e] convenient, in that they provided sem[i-] permanent or permanent liaisons fo[r] the younger sons. From the Naya[r] point of view, a Namboodiri younge[r] son was considered a good partner be[-] cause of his caste prestige. Accordin[g] to one Malayalee historian, there wa[s] a considerably larger Namboodi[ri] population in Kerala in the fourteent[h] century, and if that is true, such lia[i-] sons were more common at that tim[e] than in the early twentieth century.

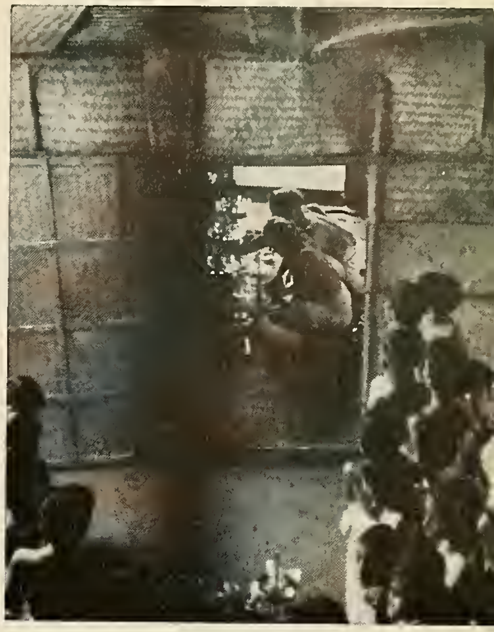
Popular entertainment is the Kathakali dance, which is elaborately costumed.

A religious procession files around the central shrine within a royal temple.

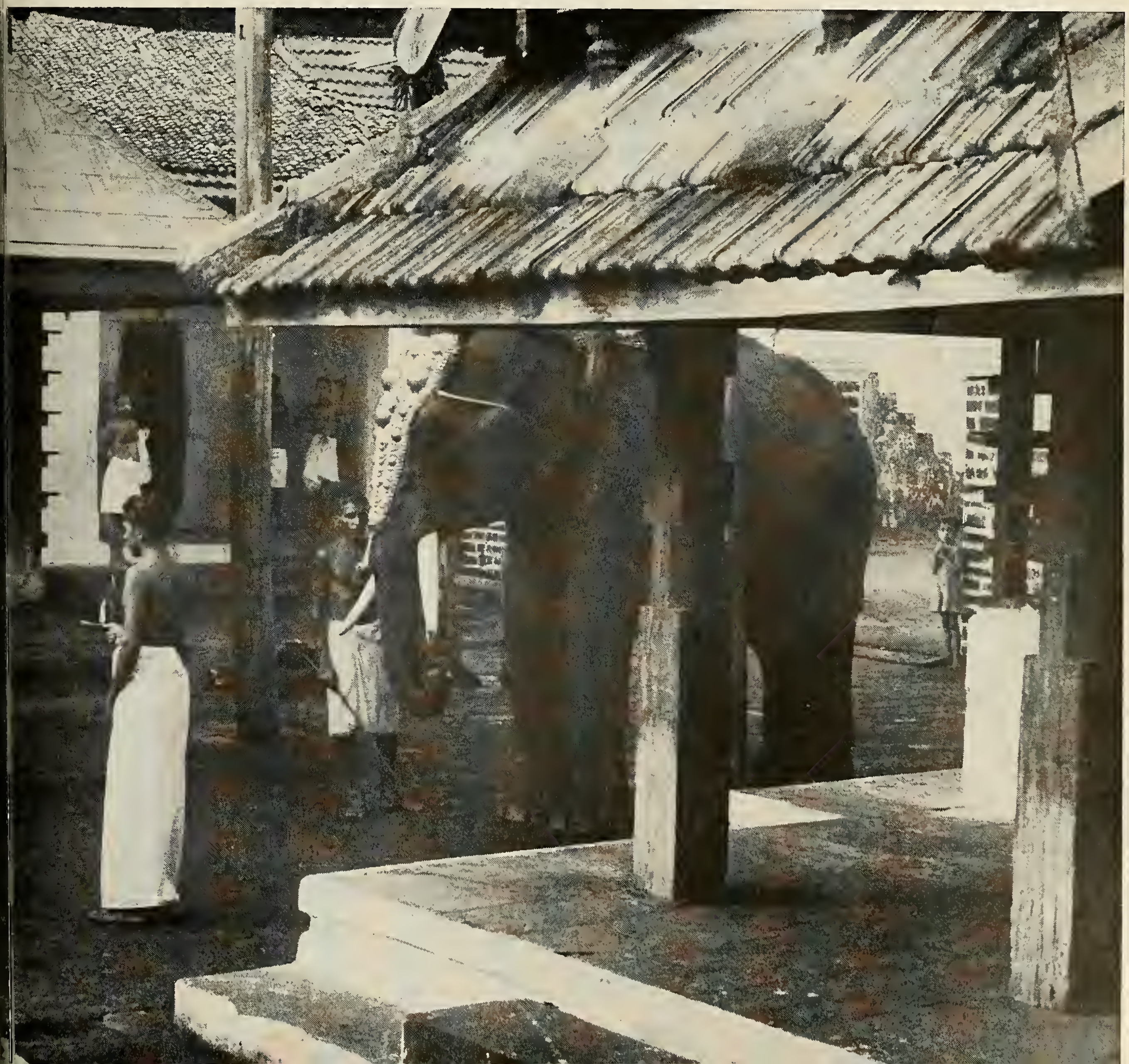
The history of the Namboodiri community still presents certain puzzles, not the least of which is the date of their arrival in Kerala. According to the legendary *Keralolpatty* (an account of Kerala history, said to have been set down in writing in the eighteenth century, more than two hundred years after the first appearance of the Portuguese on the coast), Brahmans were brought to the southwest coast of India by the godlike sage-warrior Parasurama. They settled in thirty-two *grammam* in the north (now the South Kanara District of Mysore State) and thirty-two in the south of Kerala.

It is hard to define a Namboodiri *grammam* in simple terms. Each *grammam*, at least each major one, had its own temple and its own authorities for religious and secular laws and

Namboodiri boy is dressed for study of Ottan Thullel, a classic dance form.



Namboodiri men perform special rites in a temporary shrine in royal palace.



their enforcement, although some of the smaller or lower-ranking *grammam* deferred to the authorities in neighboring major ones. Most *grammam* were somewhat localized geographically, and their *illams* were within a radius of ten to twenty-five miles of the *grammam* temple. But since the territories of two *grammam* might overlap, these cannot be thought of as communities in the usual sense.

There does not seem to be any factual basis for the legend of Parasurama. The majority of modern historians hold that the Namboodiris came to Kerala sometime between the first century B.C. and the fourth century A.D. The evidence for their place of origin is slight, but all authorities agree that they probably did come from outside of Kerala, bringing with them many new customs and traditions that eventually mingled with those of the earlier inhabitants of the region.

Even the source of the name Namboodiri has been disputed. Perhaps the most reasonable suggestion is that its root is *nambu*, meaning "sacred" or "trustworthy," and *tiri*, which literally means a "light," but which is often used in Kerala as a high-caste honorific suffix. Today, the caste name Namboodiri, or Namboodiripad, is often used as a surname. The term *pad* added to the name usually indicates that the man belongs to the highest of the Namboodiri subgroups.

There is also considerable argument among Malayalee historians as to when the Namboodiris became landed aristocrats, if they have always practiced primogeniture, and on many other related questions. Further, the relationship of the Namboodiris with the matrilineal castes has also been a matter of speculation. Some Malayalee historians believe that the Nayars of Kerala were not matrilineal before the tenth century A.D., but that they became so under the pressure of a hundred years of intermittent warfare with the Chola empire on the east coast. Others maintain that Nayar matrilineality has had a far longer history, perhaps deriving from a matrilineal tribal system, perhaps from an earlier bilateral system, in which equal emphasis was given to the mother's and father's sides, and property could be inherited from either or both parents.

Perhaps the only aspect of their history that is known definitely is that the heyday of the Namboodiris lasted from the twelfth century until the end of the seventeenth. During that time, the political structure of Kerala was feudalistic, resembling in some ways the continental system of Europe in the thirteenth and fourteenth centuries. The petty chieftains sometimes exercised the right of taking up arms among themselves, and on occasion even waged war against their own feudal heads. Many important temples had their own *Samketams*—well-defined areas in which Namboodiri temple authorities acted as civilian petty chieftains and had sovereign rights.

Namboodiri *grammam* dealt only with Namboodiri affairs, and had no say in the relationships between individual Namboodiri families and their tenants of the Nayar or lower castes. On the other hand, the Namboodiris had the unique role of being above and beyond territorial concerns. They could move freely from one area to another, even between two at war.

Namboodiris were ranked in several ways on the basis of the privileges they possessed—to some extent by their wealth, and in part by their occupation. According to the Cochin census report of 1901, "special privileges in

Nayar women leave after worship in a temple that is in Namboodiri household.

Young Brahmacharyya boy must dress only in a loincloth and leather strap

Traditional folk dance, Kaikuttykali, is performed by these Namboodiri women.

Jewelry, much of it made of solid gold, is worn only for special occasions.

regard to the performance of religious rites and . . . matters of a purely social nature serve as the best basis for a subdivision of the Nambutiris in the order of social precedence as recognized amongst themselves."

There were ten of these privileges, including the right to teach the Vedas (the four earliest sacred texts written in Sanskrit) or Shastras (books of sacred law composed later than the Vedas); to perform sacrifices; to officiate as family priests; to become a *sanyasi*, or holy man; to study the Vedas; to perform priestly functions in temples; to cook for all classes of Brahmans; to take part in certain semihumorous "shows"; to bathe in the same place with other Brahmans; and to eat in the same row (*literally* in a row) with other Brahmans. These rights were listed in a traditional order: those possessing the first had the right to the remaining nine, those possessing only the third had the right to three through ten, and so on.

The geographic distribution of the Namboodiris seems always to have been uneven. In certain areas there were thick concentrations, while others contained a few *illams* at most. It is striking but, under the conditions, not surprising, that the largest number, including almost all of the high-ranking ones, are to be found where the greatest amount of land could be given over to rice cultivation. Apart from gifts by local rulers and the like, most of the Namboodiri wealth came from the land. On the other hand, the owners refused to deal directly with that land, preferring to leave agricultural management to tenants. Throughout Kerala, rice, and occasionally coconuts, have been given over to tenant cultivation, whereas the majority of cash crops, such as pepper, have been cultivated by Nayar or Moslem landowners with the help of hired laborers.

Traditionally, as we have said, the property of a Namboodiri *illam* could never be partitioned. One result has been that the Namboodiris survived as a landed aristocracy, in contrast to Brahmans in other parts of India, where the family property was divided every second generation or so.

The Namboodiris were also considered to be the highest spiritual authorities in Kerala, and the repositories of learning. They were well versed in Sanskrit literature and were skilled at composition and teaching in that language. The Namboodiris were also extremely strict about rules of pollution. Indeed, Kerala, because of its dispersed settlement pattern and loose political structure, has been the one place where the concept of "distance pollution" has been most highly developed. Thus, a Nayar was allowed inside a Namboodiri house, but he could not touch anyone or enter the kitchen or the *puja* room (where religious rituals are performed daily). A Namboodiri male with a Nayar wife would go to her only after his evening meal and would leave in the morning before his purificatory bath.

MEMBERS of the lower Nayar castes, such as washermen, were allowed only on the veranda of the house, and members of the various service castes, such as blacksmiths or carpenters, were expected to remain in the compound and not come near the veranda, although an exception was made for a carpenter carrying his tools. In descending order, each caste group had a specified distance to maintain from the Namboodiri house and from individual Namboodiris.

Many traces of the accent on distance pollution still exist. Obviously,

Ritual purification ceremony is being performed with traditional implements.

they cannot now be enforced on the road or in a public place, but in a Namboodiri's own compound he can require that members of lower castes maintain the requisite distances. On the whole, the younger Namboodiris, both male and female, say that they do not believe in or practice the restrictions and privileges.

Traditional life was simple and austere. At the age of about seven, Namboodiri boys entered upon a period called *Brahmacharyya,* which lasted until they were almost fifteen. During this time they were supposed to study the Vedas and to undergo certain deprivations: for example, they were not allowed to sleep during the daytime, and were expected to abstain from all luxuries, including clothing of all kinds except for a small strip of cotton cloth and an inch-wide leather strap across one shoulder. The teacher (guru), was empowered to punish them severely for the slightest error.

GIRLS remained at home. Usually they were taught to read and write either by an older member of the family, a teacher who might be of a slightly lower caste or, occasionally, by their mothers. The sole purpose of this education was to enable them to read the sacred epics—that is, the *Mahabharata,* the *Ramayana,* and the *Bharatham,* the last a book devoted to the experiences of Lord Krishna. In the sixth year, there was a ceremony for "removing the hair"; until this time girls were not allowed to let their hair grow long. After the ceremony, in which only a small piece of hair was cut off, the observance of "touch pollution" began. A girl was expected to fast every Monday and to pray to God for the longevity of her husband-to-be, for the death of the husband was usually blamed on the wife.

Traditionally, there was a tendency for a girl to be married to someone who lived within two or, at most, three days' walk from her parents' *illam,* often within the same *grammam.* Today, although many marriages are with nearby *illams,* some girls marry men who live as much as 200 miles away, although this is rare. Among today's educated Namboodiris, considerations of wealth and education play some part in selection of a husband.

Because of the problems involved in getting a girl married, any offer was normally accepted. There was a saying among the elderly Namboodiri women: "Even if it is a monkey of our own caste who asks for a girl, we must give her." Postpubertal marriage was most frequent, but younger girls were also married. Dowries were, and continue to be, extremely high, despite legislation prohibiting them. In 1962, they ranged from $1,000 to almost $5,000, not including the cost of the wedding and the attendant ceremonies. (In rural India, $1,000 buys as much as $4,000-$5,000 in the United States.)

At one time, men often took second and third wives in exchange for getting their daughters married, thus escaping some of the heavy burden of dowries, but this has stopped completely since the enactment in 1956 of a bill prohibiting Hindu polygamous marriages. Today, when a man has difficulty getting his daughter married, he sometimes tries to get one of his unmarried younger brothers to take a wife in exchange. Brother-sister exchange is becoming more common because most of the men now marry Namboodiri women. In marked contrast to the rest of south India, they do not allow marriage between first cousins. Marriage to a more distantly related member of one's mother's natal *illam* or to a relative of one's father's sister's husband is permitted.

The traditional position of the woman was extremely difficult. After marriage a girl had no right in her parents' house. Until her death she lived in her husband's house and could only visit her parents if her mother-in-law and husband gave her permission. As one young girl put it to me: "Whether she was happy or miserable in the husband's house, she had no other choice. Sometimes the man had one or two other wives, and those elder sisters [a term sometimes used for elder co-wives] might have hurt her because they were jealous. Still she was expected to live with all this and think only pious thoughts about God and attend to her household duties."

IT was not uncommon for a twelve-year-old girl to be married to a man in his sixties who had several wives. He might have married the younger girl in order to get one of his own daughters married. The young bride was expected to observe *gosha* (a kind of purdah) and not to allow any man other than her own husband, sons, and stepsons to see her. When her husband died, she was not allowed to remarry, but was forced to devote the rest of her life to piety.

At the end of the eighteenth century, the British took over direct political control in Malabar, and came to play a major role as advisors in Cochin and Travancore. At that time, the Namboodiris, deprived of their political role but still maintaining their status as religious authorities, withdrew to their estates. Their attitude at that time is illustrated by the words of an elderly Namboodiri man: "When the British came, we were sitting with hatred in our minds towards these people and towards their education. Our real eminence came in things like the Murajapam [56-day Vedic recitation] in Trivandrum."

While the Nayars took rapidly to modern education, the Namboodiris remained aloof, preferring to re-emphasize their spiritual sanctity and purity. About the turn of the century Namboodiri youth, especially some of the younger sons who were brought into contact with educated Nayar males through their *sambandham* relationships with Nayar women, became aware of the growing gap between the Nayar position in society and that of the Namboodiris. They saw Nayars agitating for partition of their ancestral land, and even Nayar girls being educated and having a freedom denied the Namboodiri women. Above all, during the first quarter of

Woman has vowed to donate her weight in this case in coconuts, to her temple

the twentieth century they slowly became aware that if they agitated for change, even if it displeased the more orthodox, they might stand to benefit.

In this climate the Namboodiri reform movements began. In effect, what the reformers asked for meant the end of the traditional Namboodiri family system and the group's position as a landed aristocracy, and it is not surprising that many of the leaders of the reform movement were the "underprivileged" younger sons. It was clear that there would be a total reworking of Namboodiri life if men began to receive a modern education, if each son was allowed to marry within the Namboodiri castes, if permission was granted to partition the family property, and finally, if education for Namboodiri girls became a reality.

While some *illams* resisted reform, others took to it eagerly. The area of most rapid change was near Trichur, where a rebellion against the head of the Vedic school occurred in 1917.

In the majority of *illams* today, younger sons marry within their own community, and most boys are given a modern education. However, there is still a considerable range in orthodoxy. Some of the isolated *illams* might still belong to the early nineteenth century: at the other end of the spectrum are *illams* whose property has been completely divided, where both men and women are educated and hold regular jobs, where all castes interact with complete freedom, and which, as a result, are scarcely recognizable as Namboodiri establishments.

Most of the orthodox or wealthy Namboodiris, plus the majority of elder sons (even in modernized *illams*) and others concerned about the maintenance of their caste purity and their economic and social privileges, have tended since 1947 to align themselves with the Congress Party (the political party of Nehru and Shastri). On the other hand, many of the women and younger sons accept Marxist or Communist ideologies. Some members of the reform movement have, of course, stayed loyal to Congress, at the same time siding consistently with the more socialist-minded members.

It is clear that as more and more Namboodiri young people are educated and enter various occupations, they will become less differentiated from other Kerala castes. (It is impossible to know how many Namboodiris there are today. There has not been any census conducted on a caste basis for thirty-five years.) Fewer and fewer are studying the Vedas and learning how to maintain traditional rituals. However, they probably will remain relatively highly placed. Even with land limits currently being introduced all over India, they are well off compared to the lowest castes. In another sense, the Namboodiris are a part of the newly emerging middle classes, for as individuals they are clearly in transition from one social system to another. One might safely predict that the unique Namboodiri culture will slowly disappear.

Rhesus Monkey Bands

SOCIAL PATTERNS ARE STUDIED IN PUERTO RICO

by JOHN G. VANDENBERGH

The behavior of many non-human primates has been extensively studied in laboratory environments. However, a different setting becomes necessary for certain types of studies or for those involving large groups of social animals. For instance, when questions are asked concerning population dynamics, certain aspects of reproduction, or social behavior within or between large groups, the laboratory no longer can provide the answers. Wild, or natural, populations of a species become the most appropriate to study, and within the past ten years the results of a number of such studies have appeared (NATURAL HISTORY, August-September, 1963, and January, 1964).

An alternative to an examination of an animal in its natural habitat is the study of artificially established colonies on islands. For certain purposes, such island colonies are more appropriate settings than are the indigenous homes of the animal, because the population, now restrained by a water barrier, can be studied over long periods of time. For instance, members of an island colony can be identified by tattoo or other distinctive marking and their development recorded, or bands can be altered artificially by introducing or removing individuals. Any changes in behavior that might result from human manipulations can be recorded even if they occur years later. Also, observational restrictions imposed by conditions in the natural range of the animal are largely removed. These restrictions include local taboos, difficult terrain, and the practical problems encountered in attempting to maintain scientists in remote areas of the world. This report, then, will describe some of the studies being conducted on colonies of rhesus monkeys, *Macaca mulatta*, on Caribbean islands.

The first attempt to study the rhesus monkey in a semi-natural environment was made in 1938, when C. Ray Carpenter transferred 409 monkeys from India to Cayo Santiago, a 37-acre islet off the eastern coast of Puerto Rico. There he was able to study the sexual behavior of the free-ranging monkeys soon after their release. During World War II, the colony received minimal attention, and no studies were undertaken. Responsibility for the island was assumed by the National Institute of Neurological Diseases and Blindness in 1956, and behavioral studies were resumed, first by Stuart A. Altmann and later by Carl B. Koford. By the time Altmann and Koford studied the colony, the social bands were well organized; in fact, most of the individuals in the colony had been born there. Thus, little information was available on early social dynamics.

To fill this gap and also to permit comparisons between colonies, rhesus monkeys were introduced to two other islands, La Cueva and Guayacan. These islands lie approximately three miles west of La Parguera, a fishing village on the arid southern coast of Puerto Rico. Late in 1961 a small group of monkeys was transferred from Cayo Santiago to the two islands, and in 1962, when I began to study the

Female retrieves her infant from a juvenile that handled i roughly and growls at offender, *above*. Dominant male at right, displays its large canine teeth during a yawn

colony, 253 rhesus monkeys were imported from Indi and released. Three years of studies on the forming band on both islands at La Parguera, coupled with informatio gathered on stable bands in the older colony, permit us t draw a reasonably clear picture of the monkeys' social life

Each monkey in the colony, upon importation or withi the first year of its life, is tattooed with an identificatio number. The birth dates of all animals born on the island are known to within one to two days, and because they re main closely associated with their mothers for many year we know their genealogical lines on the maternal side. A present, 574 monkeys range freely on Cayo Santiago i seven social bands and 163 on the two La Parguera island in five bands. Cayo Santiago is so small that its vegetatio cannot support such a high population, and supplement feeding is necessary. The La Parguera islands are large and have fewer monkeys, but the usable vegetation is lin ited because of an arid climate. Only after tropical storm have provided a heavy rainfall does an appreciable amou

of natural food become available. An abundance of insects and other invertebrates are always on the islands, but they are rarely eaten by the monkeys; on only two occasions has a monkey been seen to eat an insect. They feed on a variety of buds, flowers, and fruits, but the bulk of their diet is Purina Monkey Chow, which we distribute about the islands in numerous locations.

A food hopper for the chow is placed at each station, and the monkeys must learn to open the lid of the hopper to get at the chow pellets. Surprisingly, a few monkeys have never learned to open the lids; they must wait until another animal opens it for them. Especially on Cayo Santiago, where the density of monkeys is high, the feeding stations are focal points of activity, often influencing a band's movements and creating artificial tensions. Bananas and other fruits are preferred by the monkeys, and investigators use these to attract the animals into traps.

All the social bands on the islands, except one that will be discussed later, are composed of males and females of all ages. For descriptive purposes, the seven bands in the older colony of Cayo Santiago are perhaps more typical than those in the recently formed colony. The number of monkeys in these bands varies from 20 to 177; 81 is average. The same number of males and females are born, but because of differential mortality, females outnumber males by almost three to one by the time the monkeys are adult.

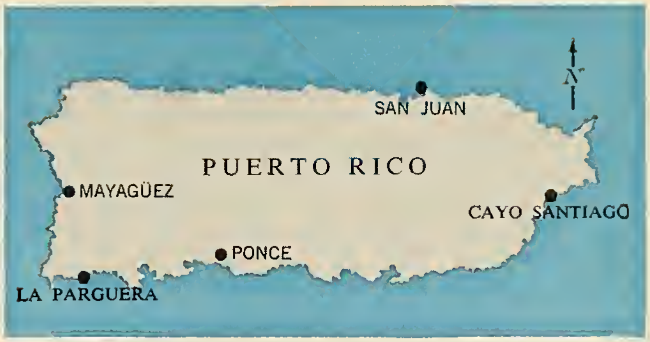
The mortality of infants averages about 10 per cent per year, with no difference between the sexes. About 5 per cent of two- and three-year-old animals die each year, and there is a somewhat higher death rate among young females. Beginning at age four, however, male mortality rates are approximately double that of females. Many factors may produce this difference, but the effects of the different social conditions faced by males and females during puberty and adulthood seem to be most important. Puberal and adult females stay in the central part of the band, where they associate closely with their mothers and remain under their protective influence. Most adolescent males, on the other hand, leave the central part of the band to become peripheral members of their natal band or to shift to another group. They are often lean and furtive animals, have low priority at the feeders, and are frequently attacked and wounded. As a result, these males are weakened and become more susceptible to disease. We have little data on the specific causes of death, because dead monkeys are seldom found in time for meaningful autopsies to be done.

On the average, adult males make up only 6 per cent of the total band. Their influence on a band, however, is disproportionate to their numbers. Typically, one to five adult males dominate the rest and are most active in the defense of the band and in controlling antagonistic behavior among its members. A linear hierarchy exists among these "control males," one of which stands out as the undisputed master. Other adult males, if present, and females rank below the control males. Among females, too, a definite "pecking order" exists, and Donald Sade, an investigator from the University of California, recently was able to rank the

When rhesus monkeys—here attracted by a scientist who is carrying bananas—are watched, they are likely to turn the tables by observing the observers with apparent interest.

female members of a small band in a linear order. This wa
a more difficult task than ranking the males, because antag
onistic encounters between females are much less frequen

We determine dominance relations among members of
band by observing their interactions. Fighting between in
dividual rhesus monkeys occurs frequently—perhaps mor
than in any other primate species—but most of the intera
tions are more subtle. A monkey has a number of ways o
expressing submission when approached or threatened b
another monkey. It can turn its head to avoid direct visu
contact; move out of the path of the approaching anima
bare its teeth in a grimacing fashion ("grin"); or turn an
stand stiffly with its posterior toward the approaching mon
key ("present"). Thus, the rank of a given animal is base
on the outcome of encounters it has had with other mem
bers of the band. Among individuals in each band, on
monkey—at least theoretically—never loses, others lose on
to specific individuals, and the monkey ranking lowest los
every encounter in which it participates. Such straight-lin



Aerial photographs show, *far left*, the islands that compose the La Parguera colony and, *left*, Cayo Santiago. Guayacan and La Cueva contain about 180 acres of land and mangrove swamps, whereas Cayo Santiago has an area of some 37 acres.

erarchies occur in some of the smaller bands, but typi- ılly the rank order is more complex. It is difficult to deter- ine dominance hierarchies among immatures because ay often cannot be distinguished from aggression.

A dominance hierarchy leads to social stability and nds to limit fighting within a band. When a hierarchy is tablished, individuals recognize their "social superiors" ıd immediately submit when a conflict occurs. Severe ghts are rare, but when they do take place, the action is vift and violent. The canine teeth of adult males often tend 15 mm. below the grinding surface of the molars ıd can inflict deep, slashing wounds. One morning we und the body of an adult male draped over a mangrove anch. The right side of his face was torn from lip to e, and innumerable deep wounds had torn his arms and oulders. Formerly he had been the dominant member of band of twenty-two monkeys on Guayacan Island; when e found the band later in the day, another monkey had sumed command. This newcomer was also wounded, and the circumstantial evidence pointed to a fight between these two adult males.

Before killing the previous leader and assuming the dominant position in the band (if such was indeed the case), the new dominant male had been solitary for six months. He lived removed from a social band, had but infrequent contacts with other monkeys, and those usually with juvenile males that lived at the periphery of the band. This solitary life in the La Parguera colony was a continuation of similar behavior the monkey had exhibited at Cayo Santiago before being transferred. As is often true of solitary monkeys, he had ranked second in a band before adopting his solitary existence. At this writing, three males follow solitary lives on Cayo Santiago, but none remain at the La Parguera colony.

The solitary life is apparently a male phenomenon. Females have never been known to become solitary. In general, females are far less socially adventurous than males. On Cayo Santiago, 97 per cent of the females stay within the band of their birth, whereas only about 70 per cent of the males remain in their natal band.

With the exception of the few solitary monkeys, an individual exists as a member of a social system. At birth, a rhesus monkey is relatively helpless: dependent upon its mother for nourishment and protection. During its first few days its social contacts are limited almost exclusively to its mother as she carries it about, nurses it, and grooms its fur. The infant begins to leave its mother for short excursions during the first week and comes into contact with other monkeys, usually its siblings or adult females.

During this period of early exploration, most mothers attend to their infant closely and are always alert to retrieve it should a disturbance occur. As the infant grows and becomes more co-ordinated, it ranges farther from its mother, and she must resort to threatening postures or growls to protect it from overexuberant playmates or antagonistic adults. The mother's effectiveness in protecting her infant depends on her social rank relative to the other members in the band, both male and female.

Individual females vary greatly in the amount of independence and protection they give their young, and individual infants vary greatly in the amount of exploratory behavior they show. Close relationships between a mother and her offspring are not limited to infancy, but often con-

tinue into adulthood. Thus, the development of an infant within the social matrix of a band is influenced by its own propensities for exploration and play, its relationships with siblings and peers, and by the amount of independence and protection given by its mother. Its mother's rank may strongly affect the development of an infant.

Japanese scientists have found that female Japanese macaques (*Macaca fuscata*), a species closely related to the rhesus, remain within the band of their birth, and their social rank at maturity correlates with their mother's social rank. On Cayo Santiago, Koford has extended this observation to males by finding that the sons of high-ranking females become high-ranking members of the band more frequently and at a younger age than do the offspring of low-ranking mothers. Thus, we know that a relationship exists between a mother's rank and the rank her offspring will attain, but experimental data are not yet available to explain the mechanisms involved.

A female rhesus monkey usually consorts with a number of males during her two to five oestrous periods per year, so presently there is no way to determine an infant's paternity. Until young monkeys are one to two years old, most adult males permit them to clamber playfully over them, and some may take a brief, but active, part in wrestling with a juvenile. Such play periods are usually short-lived, and the adult male rapidly regains his composure and adopts his normal "dignified" attitude. In some troops of Japanese macaques adult males carry, hug, groom, and protect one- and two-year-old juveniles during the birth season. The frequency of paternal-like behavior is considerably less among rhesus monkeys. At La Parguera only three young adult males have shown similar behavior.

With the exception of C. R. Carpenter's pioneering studies, wild populations of primates have not been carefully examined until the present decade, and information has been available only from studies made in zoos and laboratories. This information indicated that primates breed throughout the year, thus suggesting that sexual attraction —that is, the complex of activities associated with mating— is an important cohesive force in maintaining band stability. More complete data are now available from numerous field studies to show that mating occurs only during a limited portion of the year in many species, and that if sexual attraction affects band cohesion at all, it acts as a disruptive influence. For example, mating in both island colonies is limited to five months of the year, and during the non-mating season the bands remain intact. In fact, far fewer shifts from one band to another occur during the non-mating period than during the mating season. The cessation of mating activities is complete for seven months; no sexual behavior is seen and histological examination of the testes shows that no sperm is being produced.

Some observations of developing bands in the La Parguera colony may indicate factors contributing to social cohesion. When monkeys were first released, small groups of two to ten individuals formed within days. Typically, membership was fluid, and individuals frequently stayed with a group for a day or two and then left to join another group. Within the first few months, small groups of adult females stabilized, and if these basic groups were joined and dominated by an adult male, a band was formed. Such bands persisted. Groups not "adopted" by an adult male disintegrated, usually within six months, and the individuals joined other existing bands.

As yet I have accounted only for the adults in the colony. Females reach adulthood at approximately three and one-half years and usually give birth to their first offspring at four years. Maturation is somewhat longer for males; they may begin producing sperm at three and one-half years, but do not become active breeders until they are five or six. Few longevity records are available, but some captive females have reached thirty years. For unknown reasons, per-

During midday rest periods, adults often sleep on branches in manner seen above, and have never been observed to fall.

Adult female seems unconcerned with juveniles on mangrove roots below her; both are watching young not in the picture.

haps chance, few immature females survived importation into the La Parguera colony. Many young males were imported, and these did not participate in the formation of basic groups nor did they join the developing bands. Instead, they formed an all-male group quite separate from the bands containing adults. Within the past six months—that is, about three years after importation and at the approach of their sexual maturity—these have been leaving the all-male group and joining more typical bands.

Thus, the stability of groups would seem to be dependent upon the presence of a basic group of mature females dominated by an adult male. The apparent inability of the young males to join the groups may have been caused by the absence of the usual kinship ties, that is, neither their mothers nor older siblings were present to provide "social support." These observations indicate that a characteristic essential for cohesiveness and stability in a social band is a system of kinship ties integrated with a hierarchy based on social dominance. At the present time, I must limit this conclusion to the rhesus monkey—and perhaps to the Japanese macaque—but as studies of additional species intensify, it may eventually have wider application.

Young adult male makes grimace indicating submission. His identifying number is just visible on the right thigh.

SKY REPORTER

Names of constellations reflect many religions and mythologies

By Thomas D. Nicholson

The celestial chart illustrated on these pages should be a challenge to "Sky Reporter" readers who believe they are familiar with the spring sky. This map, in which the constellations have been redrawn as biblical or ecclesiastical figures, includes the half of the celestial sphere centered on the autumnal equinox, extending from the north to the south celestial pole (*top to bottom*) and from the summer to the winter solstice (*left to right*). This is the same part of the sky we see in the early evening hours of mid-spring. Thus, readers should be able to match the stars of the chart (at least, those visible from northern latitudes) with those they can see on May evenings. Yet this may be something of a puzzle, for the chart represents the sky from outside looking in. The directions are those you would find on a map of the earth or on a celestial globe—that is, with east to the right. The conventional method of representing the stars is just the opposite—portraying objects in the sky as we see them from the earth's surface. Thus, when we look into the sky, facing south, east is to our left.

It should not be too difficult to find where the spring constellations belong in the accompanying illustration. Although the ones shown are different from those we know, the authors of the work were thoughtful enough to provide a key. After the names of each of the constellations there is a reference to an "alias" for each historical figure represented—the aliases being the classical constellation names. Attempt to locate the Big Dipper and the North Star, the sickle that marks the head of the Lion, the sail-shaped four stars of Corvus, and the hook-shaped body of Scorpius. Try to pick out the brightest stars of spring, Regulus, Denebola, Arcturus, and Spica—they are all there, but are not easy to find, even with their aliases, primarily because of the "outside-in" portrayal.

As an example of celestial art, the chart is unique in the subjects used and in the delicacy and skill of its drawing. The ornate figures of the saints and the cherubic border decorations make the work one of the most interesting and attractive representations of the constellations, although indeed an unusual choice of characters and objects. But the artists, Peter Schenk and Gerard Valk, were apparently not so gifted in astronomical accuracy as they were in their artistry. For example, the stars of the Southern Cross (cen-

Pagan names of the constellations were replaced with biblical characters and objects in this eighteenth-century chart of the stars. The inscription reads "A Starry Christian Sky."


STELLATI
ANI HÆ
RIUM PRIUS.
PETRUM SCHENK, et
GERARDUM VALK
S.Michael
Flagellum XPI
TRES
REGES.
S.Thomas
S.Iacobus minor
S.Benedictus
cum Spinis Eius
S.S.Abraham
et Isaac
S.Israel
S.Iacob.
Tropicus Æstivus Solstiti.
Æquinoctialis
Ecliptica.
Circulus Polaris Merid.
Polus Mundi Merid.

ter of the lower half, on the skirts of SS. Abraham and Isaac) point directly toward the south ecliptic pole. They should point—as they do in the sky—toward the pole of rotation, the south celestial pole.

It is difficult to see the justification for the selection of the particular characters, or for the locations assigned to them. The zodiacal constellations (six arranged along the ecliptic—the inclined diameter cutting through the center of the chart) were apparently picked because the authors wanted to associate the twelve traditional constellations of the zodiac with the twelve apostles. Beyond this relationship, however, the constellations represented include figures from both the Old and the New Testament, at least one animal (the paschal lamb), and many inanimate objects, with clear ecclesiastical connection. Yet there appears, for the most part, to be no logical connection between the figures chosen and the traditional constellations they have replaced. There is one exception to this in the vast, sprawling Argo Navis, the Ship; this has been redrawn and renamed Noah's Ark—a most appropriate substitution within the context of this work. But one can hardly justify the substitution of St. Peter's Boat for Ursa Major, including all the stars of the Big Dipper. It may be that some subtlety in this has no modern connotation and totally escapes us.

Judging from the location of the equinoctial colure (the vertical line extending north and south through the autumnal equinox at the center) with respect to the stars, the work can be dated astronomically. The line is shown several degrees east of its present position on the sky—where it would have been several hundred years ago—gauging it by the points at which it passes through the stars of the Big Dipper and the Southern Cross. Since then, the precession of the earth's axis has shifted the autumnal equinox and the equinoctial colure westward along the ecliptic by about 55 seconds of arc per year, or about one degree in 65 years. On this internal evidence, the chart should represent the sky of about 1700. (Actually its date is 1708.)

Most of the more familiar constellations in the northern sky were recognized in antiquity, and have their origins in the mythologies and religions of Greece, Egypt, Rome, and other early Mediterranean civilizations. Some names that have survived, however, cannot be traced to any particular time, people, or source.

The constellations began to take on significance as a geography of the heavens when they appeared in the first sky maps produced by astronomers in the early seventeenth century. In these charts, the constellation figures were carefully—and often fancifully—drawn, in order to show the positions of the stars with as much accuracy as possible. The location of a star in the sky, then and for centuries later, was its designated position within a constellation figure; for instance, Betelgeuse means "the shoulder of the giant." However, the early maps also attempted to fit imaginary figures into constellations in a reasonably suggestive way.

The early seventeenth-century astronomers who prepared the celestial charts did not find these two objectives completely compatible. When they fitted the constellations into the stars, they discovered large areas of the sky where there were no figures or parts of figures. So these map-making astronomers solved the problem by adding more constellations. First they added new constellations in the region of the sky around the south celestial pole, which had not been observed by the ancients. Secondly, they filled in the gaps between the northern constellations. Then they broke up some of the older, unwieldy, meandering constellations that filled too large an area. There was little agreement among these men concerning the new constellations that they named. The nameless parts of the sky were unassigned, and each scientist could fill them in as he saw fit, even for very personal, illogical, and unscientific motives. These astronomers often did not agree on the appearance, size, shape, position, or orientation of even the classic constellations. Some chose to ignore completely the heritage from the ancients and preferred to let their own imaginations roam over the entire sky, creating constellations entirely of their own choosing. The illustration featured in this month's "Sky Reporter" is an outstanding example of this last approach, in which a whole new scheme was used.

The last new constellations to gain general acceptance were a group of thirteen in the southern sky, named by the French astronomer Lacaille in the middle of the eighteenth century. In 1801, the German astronomer Johann Elert Bode (famous for the mathematical series known as Bode's law, which predicted the approximate distances from the sun to the planets—as far as Uranus) drew precise boundaries to the constellations. Thus, rather than designating vaguely where they were, or how they fitted, he showed concern for the exact region of the sky that a constellation was supposed to occupy. Bode's work was not generally considered as a standard by astronomers, but it paved the way for eventual acceptance by the International Astronomical Union of standardized boundaries for a limited number of constellations, all of which—taken together—filled the entire sky.

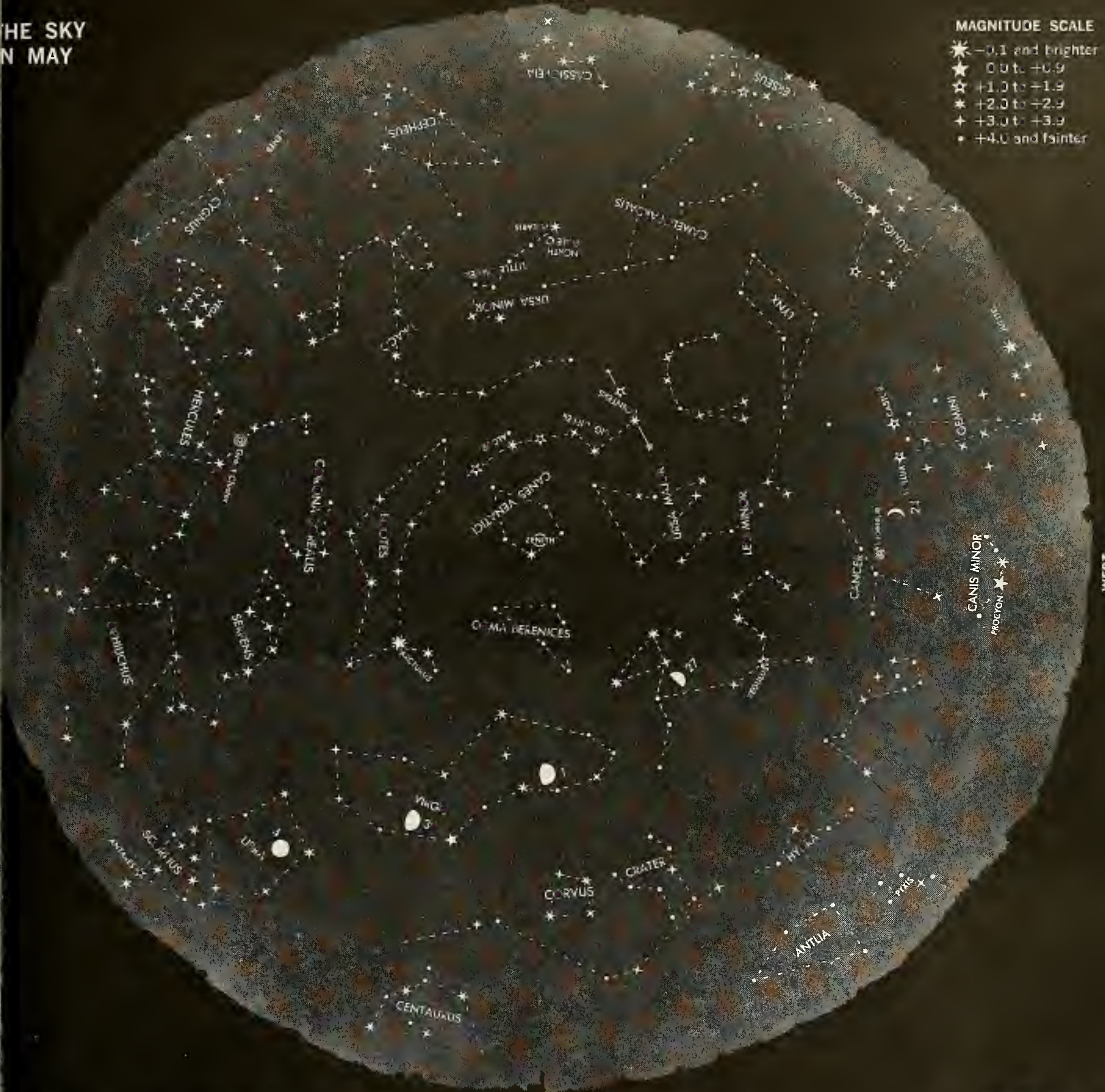
But the real significance of Bode's work was the introduction of a new concept into the use of the constellation names by astronomers. Before his time, the constellations were thought of as figures placed among the stars, with some regard for the outline of the figure and the arrangement of the stars within that figure. Today, however, the constellations are used by astronomers in an entirely different sense. They are symbolic, not of the imaginary people, animals, or objects their names may conjure up, but of a certain *area* of the sky, with fixed boundaries in a system of celestial co-ordinates. Within these areas the stars and other objects are designated with the name of the constellation in some systems of identification. For example the brightest star in the constellation Leo is known popularly as Regulus. To astronomers, however, the star is Alpha Leonis (the Greek letter A plus the Latin genitive of Leo) in the system of Bayer.

There are a total of 88 constellations accepted today in the system approved by the International Astronomical Union. Of these, 47 can be traced to antiquity, in the sense that they were in existence at the time of the Greek astronomer Ptolemy (about A.D. 150). The others were created by the seventeenth- and eighteenth-century astronomers.

As interesting as the antique chart is, it is hardly to be recommended as a source of knowledge of the spring stars for beginners in astronomy. Modern sky maps, such as the one for this month's sky on the opposite page, are certainly easier to use than are those with fanciful figures.

Dr. Nicholson, the regular author of this column, is also Chairman of the American Museum-Hayden Planetarium

THE SKY IN MAY



Full Moon	May 4,	4:01 P.M., EST
Last Quarter	May 12,	6:19 A.M., EST
New Moon	May 20,	4:42 A.M., EST
First Quarter	May 27,	3:50 A.M., EST

TIMETABLE

May 1	10:00 P.M.
May 15	9:00 P.M.
May 31	8:00 P.M.

(Local Mean Time)

May 1: Venus (magnitude −3.7) should be easy to see in the eastern sky all month long, from just before dawn until the rising sun hides it. But this morning it can act as a guide to Saturn (magnitude +1.4), a much fainter object about a degree below Venus. Conjunction of the two planets is at 1:00 P.M.

May 4: Today the full moon is accompanied by a penumbral eclipse, not visible in any part of North America because the moon is below our horizon at the time.

May 5: The Eta Aquarid meteors, a relatively sharp shower of moderate activity with fast, bright meteors, reach maximum early this morning.

May 15-16-17: There will be two planets in the vicinity of the rising crescent moon in the eastern sky on these mornings. On the 15th, Saturn will be just above the moon, and Venus will be well to the left and lower. On the morning of the 16th, the moon will be between Saturn and Venus. On the 17th, Venus will be to the right and above the upper horn of the crescent moon.

May 20: An interesting annular solar eclipse occurs with the new moon of this date, visible across Northwest Africa and Central Asia. (In an annular eclipse, the tip of the moon's shadow, although pointing toward earth, falls just short of touching the earth's surface.) The shadow's tip this day comes so close to touching the surface of the earth that the eclipse will be almost total in those areas where it is visible near noon.

May 22: The evening crescent moon and Jupiter are in the western sky tonight. Conjunction is at 6:00 P.M., EST.

May 27: Mercury is at superior conjunction, passing around the sun on the far side. It now enters the evening sky.

All Month: Of the planets visible to the naked eye, only Jupiter is in the evening sky during May. It moves into Gemini early in the month, and remains easily visible in the western sky for several hours after twilight.

Venus, Mars, and Saturn are all morning stars, but Venus is the only one that is easily seen. It rises in the east before dawn, and remains visible until about half an hour before sunrise.

The Man-o'-War Bird

By Bryan Nelson

Male frigate, *left*, with fully inflated sac displays in mangroves on Tower Island.

Tens of thousands of birds nest on this uninhabited island in Galápagos.

Puzzling behavior is studied in Galápagos

Frigate-birds, also called Man-o'-War birds because of their swiftness, are the members of the order Pelecaniformes most specialized for aerial life. They weigh only two or three pounds despite an eight-foot wingspread, and their short tarsi and tiny, unwebbed feet (they often perch with two toes forward and two backward), although excellent for gripping the twigs among which they usually nest, are not of much use for walking or swimming.

Frigates usually nest alongside substantial concentrations of other sea birds, possibly because they are partly dependent on them for food. On the waterless and uninhabited Galápagos island of Tower (Genovesa), where my wife and I camped for seven months in 1964, thousands of *Fregata minor*, the Great Frigate-bird, and a few *Fregata magnificens*, the Magnificent Frigate-bird, nest among some 140,000 pairs of *Sula sula*, the Red-footed Booby.

The male frigates are mostly black with a metallic luster—particularly on the elongated scapulars, which form a fancy cape on their backs. Females are duller and are white on throat and breast; juveniles have white heads, and their upper breasts are heavily stained with a rust color. Many authors fail to make clear the differences between the two species. The males are extremely difficult to distinguish in flight because both have, to a variable extent, a pale bar on the wing coverts (which has sometimes been said to distinguish *minor*). The slightly heavier build of *magnificens* is not obvious, and the purple, rather than green, sheen on the scapulars is useless for flight identification. In my experience, a good diagnostic character of *magnificens* is a vocal clicking note it gives in flight. The females are more easily distinguishable: *magnificens* has a well-defined black throat and *minor* a whitish one; both have black bellies. The orbital ring is bluish black in female *magnificens*, but red in *minor*, and both have bluish-gray bills.

Great Frigates catch much of their food, such as flying fish and squid, by snatching it from the surface of the sea. The long bill, with a sharply hooked end, is beautifully adapted for this feeding method. Unless heavily laden with food they can take off from water, but they seldom alight on, much less plunge into, the sea. Their plumage is not waterproof, and during their long foraging trips, which may be 500 to 700 miles from land, they live entirely on the wing, flying buoyantly, with deep, muscular strokes. Their long, forked, and flexible tails and great wingspread help them to ascend thermals, and the height so gained allows them to scan a greater area for food.

Frigates are keen scavengers and pirates, materializing from apparently empty skies whenever there is a chance of food—for instance, when fishermen begin gutting operations. They show exquisite co-ordination and timing in

Booby with full crop is pursued by a frigate, which will try to steal food.

snatching food from either sea or ground. If a booby spills fish while feeding its young, a frigate swoops headlong, wind whistling through its primaries, checks slightly, and plucks the fish from the ground before the booby can move. Where there are many frigates, the mere act of passing food from parent booby to offspring, or even from frigate to young, is hazardous. One often sees a juvenile frigate and its parent forcibly sundered when an adult male swoops down to take the fish as it is actually being passed from throat to throat (frigates feed their young by incomplete regurgitation). Females rarely attempt such bold tactics, and juveniles never do, as feeding behavior in all highly specialized species takes time to perfect.

Both frigate species harry boobies, although there may be a difference in the extent to which they do so; some authors think that *minor* is more inclined to fish for itself than is *magnificens*. We could not decide exactly what stimulus elicited the chasing behavior. The hour or two before dark, when Red-footed Boobies stream home from fishing, is obviously the best hunting time, yet some boobies pass through the frigate belt unscathed while others are attacked. Maybe the former are "empty" or are unusually obstinate, but they would have to be very obstinate indeed to withstand the rough treatment they receive.

Perhaps the initial stages of the frigate's attack are relatively unselective, and the quality of the harassed booby's distress call (an agonized "arrk") provides the main clue. Those with full crops utter, in their extremity, a strangled, wheezing cry caused by the pressure of food on the windpipe. On occasions when the frigates seem to know that their victim has food, a mob of six to ten hem it in, relentlessly following every twist and turn. Sometimes, while still in flight, one or more frigates seize the booby by tail or wing tip and capsize it. In the few seconds before throwing up its catch, the booby, with bent neck and downward-pointing beak makes violent efforts to regurgitate. The frigates recognize this intention movement and redouble their efforts; such boobies never escape tax-free. Usually only one frigate gets the fish, but the others break off the chase, leaving a highly agitated booby that has crash-landed in the sea.

Frigate piracy is spectacular but not, I think, significant in booby ecology, except where a relatively small population is harassed by a large number of frigates. Certainly it was not a serious handicap to the huge booby population of Tower, where only about 12 per cent of frigate chases were successful. Frigates were even less successful with species such as Swallow-tailed Gulls, *Creagrus furcatus*, and Red-billed Tropic-birds, *Phaëthon aethereus*.

Frigates react strongly to moving objects, as they must to catch flying fish in mid-air, and almost anything releases their chasing and catching behavior. Newly fledged shearwaters are flown down repeatedly, picked from the water, dropped, and picked up again until they succumb, although they are not eaten. Even warblers are often chased—a ludicrous sight—and a ball thrown into the air frequently

In a chase, *top*, one frigate tries to steal nest material from another. At bottom, female arranges twigs in nest.

causes a chasing behavior response.

Crouching in the low, green, succulent *Cryptocarpus* shrubs that fringe the small coral beach of Darwin Bay, scores of free-flying juvenile frigates scan the skies for the approach of their parents. The juveniles mark the beginning of a new nesting season rather than the end of an old one, since they take so long to become independent of their parents that the new season is well under way before they cut the "apron strings." Their food-begging call, which resembles the grating squeal of an angry pig, is scarcely less attractive than the accompanying hunched bobbing, with head cocked sideways and one eye on the sky.

In January, 1964, almost all the young frigates in the area were on the wing, although they returned regularly to be fed at the nest. In July their parents were still feeding them. This long period of post-fledging feeding shows the effort involved in rearing a young frigate to independence. It probably also reflects the species' highly specialized feeding method, which takes so long to perfect that the young must be fed for six months after they first become capable of flight, and so can survive repeated failures to catch their own fish.

THIS MALE has just begun to display. Head is not thrown fully back, and the sac has not yet been totally inflated. Note way in which feathers are flared.

We were astounded to find that, despite their post-fledging feeding, several juveniles died of starvation in June after dropping in weight to some 600 grams—a miserable $1\frac{1}{4}$ pounds for a bird with an eight-foot wing span. Despite their long-subsidized learning period, these young were not fending for themselves even at bare subsistence level. Weighing revealed the following picture: juveniles weighed on April 18 averaged 1,083 grams, and twelve weeks later the average had dropped to 983 grams, compared with the average adult weight of 1,430 grams. Thus, not only were juveniles much lighter than adults, but after six months free flying they were still losing weight.

Instead of a seasonally abundant food supply, the frigate probably experiences a food situation that can fluctuate erratically. The bird cannot, therefore, evolve a breeding cycle that produces independent young precisely when food is most plentiful. On the other hand, it can afford to continue feeding its young for an extremely long period because there is no season during which food is *predictably* scarce. These factors are graphically reflected in the length of the young frigate's post-fledging feeding period and its obvious difficulty in achieving independence.

The frigate's breeding cycle is more than twelve months from pair formation to abandonment of the juvenile. It is thus likely that, even assuming the maximum possible breeding success, frigates produce, on average, considerably fewer than one young per year. In fact, breeding success is far from high, if the colony on Tower was representative. There the 1964 breeding season started in January, with the blossoming of the male's huge red gular sac — his nuptial adornment. When fully inflated, this structure feels like a warm, tight, rubber balloon. The surface is seamed with a network of capillaries, which exude drops of blood whenever the sac is punctured by a thorny twig or the sharp bill tip of an opponent. These scarlet sacs are a memorable sight, couched between the vibrating black wings of frigates displaying among the green *Cryptocarpus* or in the dry, lichen-silvered branches of the Palo Santo trees.

During the male "advertising," the sac is inflated and displayed to attract females that fly overhead. Displaying males turn their widespread wings forward so that the silvery undersurfaces reflect the sunlight like a mirror. The male enhances the effect by violent wing trembling and constant swiveling to orient himself toward the flying female. The display is lifted to a bizarre level by the scarlet of the distended sac and the passionate, high-pitched warble that the frigate utters as it throws its head back and turns it from side to side.

Frigates may display singly or in clusters of up to twenty birds. A displaying male attracts others, and the group grows. At this stage there is no aggression between competing males, although often they do compete simultaneously for the attention of a single overflying female. Females appear singly or in small numbers, and as one cruises above she evokes frenzied display from a whole group of males; we

Female alights next to a displaying male. Red-footed Booby is at the right.

recorded thirty males in one cluster displaying simultaneously to one female. In dense colonies, displaying males are commonly in bodily contact, so the effect of such a concerted outburst is extremely dramatic. A group of males may remain in one area for several days, by which time a proportion of them have attracted females and formed pairs. The remainder then disperse and join other groups, the center of activity constantly shifting from place to place in the colony. One may see a displaying male, after a period of inactivity, take off and, impeded by his great, wobbling sac, fly off to some other area.

The male display attracts females, which fly lower and eventually land close to a particular male. One can watch the same female visiting more than one male, sometimes widely separated. The part played in pair formation by female choice is obviously significant, as it is in many other species of birds and mammals.

As in many sea bird species, the meeting of the pair is followed by a mutual display that serves to strengthen the pair bond and is particularly lengthy and intense in the early stages of pair formation. The female usually lands opposite a male who is displaying ardently with outspread wings, and finds herself literally embraced by him. Frigate pairs meeting at the nest or nesting bush perform a mutual head waggling, from a rather crouched position, bending in unison to touch or grip the twigs, shaking their heads from side to side, and in the process rubbing their beaks and heads together and thus receiving tactile stimulation.

They crouch in this position for hours, looking most affectionate and, at intervals, breaking into the mutual head-shaking display with calling. The male continues to warble, as in his advertising display, and also utters a fine-drawn rattle, like the winding of a fisherman's reel; the female chuckles hoarsely as the counterpart to the male's high, falsetto notes. Usually the male's sac slowly deflates when the pair is together, although it may remain inflated for some hours.

Frigates probably often form permanent pairs, like most large sea birds; they also probably form permanent attachments to a particular nest site. Yet all males that intend to breed display in each new breeding season and are not highly selective in the initial phase; far from responding only to their old mate, they display to several different females and will form a pair with any of them.

In order that old pair bonds may be maintained—and bear in mind the male's readiness to accept new females—it seems that it is up to the female to respond selectively to her old mate and re-establish the relationship. By association she will inevitably have a strong tendency to return to her old site, on which she fed the juvenile for so long, and it is likely that in most cases she will succeed in pairing with her old mate. In many instances the pair re-forms on the excreta remaining from the previous nesting; young frigates do not wander far from the nest, and even juveniles tend to sit there between feeds, so their excreta form a solid pad that endures until the next nesting. In experienced frigate pairs the advertising display and the subsequent mutual display may well serve to synchronize the pair

Head waggling and "embracing" of female are usual behavior patterns

members physiologically by bringing them into breeding condition harmoniously. In birds that pair for life, the co-operation between pair members takes time to build up, and is important for breeding success; mutual displays help produce this co-operation.

Since the frigate's breeding cycle takes considerably more than a year (if the six-month post-fledging feeding period that we observed on Tower is normal), it follows that they cannot breed annually. Yet, from the few existing records, it appears that frigates on Tower nest at much the same time each year — certainly not at widely differing periods. These two facts, if we can depend on them, must mean that there are two groups of frigates, which, if they are successful, breed in alternate years—a most interesting and unusual phenomenon.

At this point I would like to recount the extraordinary state of affairs we found in the dense frigate colony on Tower. In about 4,500 square yards of *Cryptocarpus* shrub, 212 frigate nests were built between January 20 and May 20, 1964, a concentration probably as dense as frigates ever nest.

After pair formation, the male alone gathered nest material, while the female guarded the site and built the nest from the twigs he brought. The labor involved in accumulating this material is tremendous; each small twig is won by hard chase of a booby or another frigate, and delivered only after evasive action to and fro across the sky before the frigate's final descent to the nest in a spectacular, tightening spiral that throws off the last pursuers. It seems a hard way to gather nest material, but it also seems to be "in character." The female spends up to six days continuously at the nest before laying the single egg about three weeks after pair formation (early nests remain empty longer than late ones).

Fresh eggs are chalky white and weigh 69 to 96 grams (an average of 85 grams in 24 eggs weighed), which is about 5 per cent of the female's weight. Laying takes about two minutes. The first long incubation spell is taken by the male, which may take over as little as four hours after the egg has been laid, although if he is away feeding, the female may incubate for up to eight days after laying. The visual stimulus of the egg seems to act as a switch mechanism controlling the male frigate's sac inflation and display. Males guarding eggs never display, and their sacs slowly shrivel. We never saw an incubating male frigate with a distended sac.

So far there had been nothing unusual in the pattern of events. Old males had (presumably) returned to old nests, displayed, attracted some other males that were breeding for the first time, and had eventually (again presumably) in many cases acquired their previous partner. Some of the young males breeding for the first time had acquired mates and formed pairs near the experienced birds, while the remainder had moved to other nuclei to try again. However, soon after egg laying was seriously under way, a dramatically high proportion of pairs lost their eggs. From our completed records we know that 205 out of a total 315 eggs (65.1 per cent) laid during this season were lost before hatching—an astonishingly high figure.

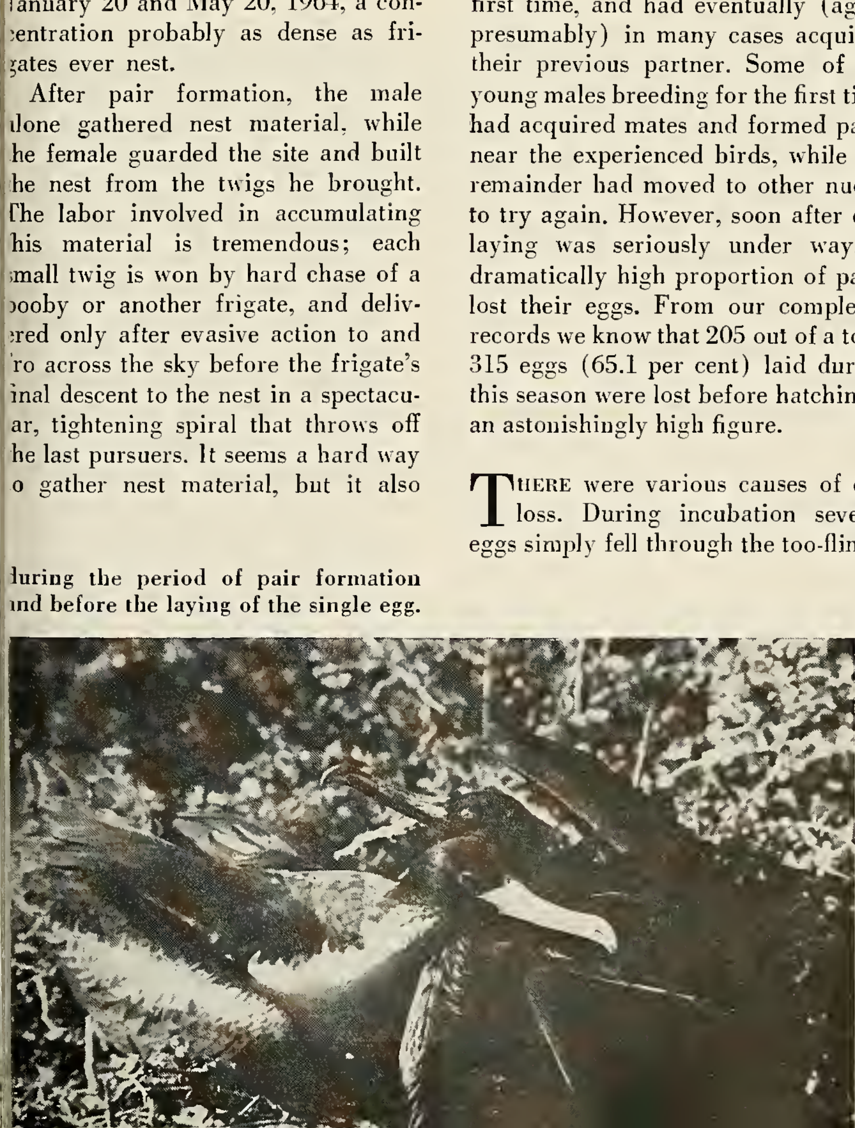
There were various causes of egg loss. During incubation several eggs simply fell through the too-flimsy nest. Others were lost during nest relief, or change-over, when the incubating partner was relieved by its mate. The incomer, eager to incubate, pushed against the partner, which had to disentangle itself from the twigs of the nest. It usually did so by raising its wings and beating them gently to give itself greater ease of motion. If the nest was at all flat, this movement caused the egg to roll out. Fifty per cent or more were lost under circumstances suggesting direct interference from a third party. This third category introduced several mysteries, but let me first deal with the other two.

The flimsy nest is partly a reflection of the difficulty of gathering nest material. The premium on such material is shown by the almost unbelievable attraction an unguarded nest has for other males. In several cases the time lapse between an owner leaving and an intruder arriving at the nest was less than five seconds, and often four or five such intruders made an almost simultaneous dash for an unguarded nest. Sometimes when we approached an incubating bird, it would make slight intention movements of leaving, and even these subtle hints were enough to bring down the ever-watchful "thieves." Yet the site, per se, has no special attraction, and once bereft of nest material it is no longer visited by interlopers.

Egg loss during change-over suggests one possible reason for the frigate's long incubation stints; the average of 80 spells was $9\frac{1}{2}$ days for males and $11\frac{1}{2}$ days for females, with maximums of 15 and 18 days respectively. Thus, during the 55-day incubation of the egg, nest relief occurs only four or five times. If frigates changed over as often as, say, the Blue-footed Booby, *Sula nebouxii*, this number would be 90 or more, and the danger of egg loss correspondingly higher.

I should not imply that this is the only reason for the frigate's long incubation stints. It is possible that another reason lies in its feeding methods, which require such long foraging trips. However, the length of an incubation period reflects both the needs of the adults and the interests of the egg, and the latter are served by having the fewest possible nest reliefs. During an unbroken incubation period of 10 to 15 days, frigates lose up to 20 per cent of their body weight—a substantial loss for such light birds. Replacement of metabolized reserves, which

during the period of pair formation and before the laying of the single egg.



YOUNG BIRD, above, is about a month old. The precocious scapulars form the black "cape." At right, a juvenile female suns. Note that the wings are slightly rotated outward. This permits sunlight to reach to underside of the feathers.

consist, not of "ready food" in the crop or stomach, but of fat deposits, may well require comparatively lengthy feeding spells. It is likely that the 10-to-15-day stints represent the best compromise between the interests of the egg, the maximum possible length of stint, and the optimal facility with which adult reserves can be replenished after depletion. Shorter stints would mean less depletion and easier replenishment, but also more nest reliefs. Longer ones would require greater depletion, which would perhaps be physiologically harmful.

THEN we discovered a puzzling situation. Often, within minutes after egg loss that occurred during female incubation stints, a male arrived at the nest (which the female had left unattended), quickly inflated his sac, and began to display. Was he the original owner or an intruder? In some such cases our regular checks, carried out every few hours, told us that the owning male had been away for only a comparatively short period. Could he already have been to sea, replenished his food reserves, returned, and been cruising around keeping an eye on things from above while his mate incubated? It seemed most unlikely. Why should he be around the colony during this recuperative period after a long incubation stint, and if he really was in the vicinity, why was he ordinarily never seen at the nest for the whole of the female's incubation spell?

No, it did not seem that the male displaying on the nest that so recently had lost its egg could be the original owner. Yet he often quickly attracted a female; in some cases, within less than an hour of egg loss a pair of frigates was at the nest. If the male was a new one, an intruder, who was the female? In many cases, she was undoubtedly new. We could be sure of this, since some females that lost their eggs and then failed to show up again were individually recognizable by means of patches of dye we had put on their white underparts. Clearly, therefore, in at least some cases (possibly many) the nests that lost their eggs were quickly taken over by opportunist males and new females. The previous owners simply disappeared, or in some cases, possibly, the female later returned, since occasionally a second female came and sat near the nest, now taken over by the new pair.

This take-over procedure was, in itself, a highly unexpected discovery for us. Many sea birds are extremely aggressive territorially; it would, for instance, be inconceivable that any species of booby could lose its nest site to an intruding male in the middle of the season. Even if they lose their egg, they usually continue to attend the site, and would certainly drive away any intruder. Yet here were frigates losing eggs and nests to intruders, not rarely, but regularly.

Nearly every nest had at least one whole or broken egg lying on the ground below, while some had two or even three. Often eggs disappeared less than 24 hours after laying, and always there were the same questions—what caused the egg loss and who were the subsequent occupants of the nest? Often, too, the original pair must have remained in possession, because a new egg appeared 4 to 10 days after the loss of the old one, and a new pair could not have come together and produced an egg in so short a time. So there seemed good evidence that some pairs lost eggs, remained in possession of the nest and re-laid; others lost eggs and were replaced by newcomers; still others lost eggs, disappeared, and were not replaced, although the nest material was invariably stolen.

The whole situation was extraordinarily interesting. Two-thirds of the

JUVENILE pushes head inside female's mouth for its food—often flying fish.

breeding effort was being wasted through persistent destruction of eggs and even young, for there was a good chance that the frigate chick would come to grief one way or another. Thus, several small chicks, left unguarded, were attacked and killed by intruding males. We were astonished to find that in two cases the rightful male sat near the nest while an intruder pecked his chick and would have killed it but for our interference. Then the male parent went to the nest and fed and brooded its offspring. But why was he permitting the intruder to trespass and attack his chick so flagrantly, without attempting to drive it away? In some cases, intruding males often took over nests after actually causing egg loss and then acquired a new female, so it was clear that there were both surplus males and females in the population. There were plenty of sites, so why did they not pair normally instead of disrupting the reproduction of other pairs?

One factor may partly explain this strange situation. Nest material was clearly so scarce that frigates had an enormous incentive to take over ready-made nests. Yet this factor alone seems inadequate to explain such an important effect on breeding success. It would be of great interest to know if our experience of a frigate breeding season was typical.

There remains one more striking feature of frigate breeding biology. The egg hatches after a 55-day incubation period and, at first, the young are constantly brooded. Whichever parent happens to be incubating when the egg begins to chip (it doesn't need to hatch to release the response) undergoes a striking change in routine and remains away only one or two days, instead of the usual 10 to 15, after relief. The partner, of course, responds similarly to the hatching egg or young chick, so that the new regime is established between the pair. This, in turn, insures that the tiny chick does not have to survive long periods without food. Later it can do so.

When the chick reaches the age of 23 to 39 days, it is left unattended. By this time it weighs about 300 grams. It is incapable of adequate self-defense and, in fact, falls prey to other frigates or, on Tower, to the Galápagos Short-eared Owl, *Asio galapagoensis*, and on some other islands to the Galápagos Hawk, *Buteo galapagoensis*. We recorded 31 chick deaths (out of 110 chicks that hatched successfully) occurring within the first few days they were left unattended. Considering the relatively small proportion of eggs that survived to the hatching stage, this is a considerable mortality. One may well wonder why the adults do not guard their chicks for two or three weeks longer and so insure their survival. After all, they will feed them for another four months before they fly. But that is another frigate puzzle.

The subtlety of the adaptations—morphological, physiological, and behavioral—that fit an organism for its way of life are rightly stressed in scientific investigations, but it would be interesting to study the evolution of non-adaptive features in biology. The frigate would be a good subject indeed.

Hideaway for Moths

Some adults live in the hair of two- and three-toed sloths

By Richard S. Casebeer and Charles L. Hogue

Unlikely partnerships in nature are common. Well-known examples are the flagellate protozoa that live in the intestines of termites and facilitate the digestion of cellulose, or the little fish, *Nomeus*, that lives with impunity among the deadly stinging tentacles of the Portuguese man-of-war. Less well known are the moths that live among the long, dense hairs of sloths. The precise symbiotic relationship between the "sloth moths" and their unlikely hosts is still a mystery.

Three species of pyralid moths of the subfamily Chrysauginae are known to live as adults on the two genera of sloths. *Choloepus* and *Bradypus*. The moth *Cryptoses choloepi*, first discovered on and described from *Choloepus hoffmanni*, the two-toed sloth of Panama, is represented by the largest number of specimens in museums. At the Los Angeles County Museum we have large numbers of *Cryptoses* from both sloth genera that were collected during three years of field work in Costa Rica. The other two species of moths, *Bradypodicola hahneli* and *Bradypophila garbei*, have been found on one species of Brazilian three-toed sloth, *Bradypus infuscatus*.

All three of the moth species are rather small—approximately 10 mm in length. Their wings are a dusky dark brown, and several longitudinal light streaks, or lines, mark the fore pair. Their bodies are somewhat flattened, but these insects are otherwise distinguishable from their close relatives and each other only by identifying anatomical details.

Dusky brown moth, at left, *Cryptoses choloepi*, was collected from the hairs of a three-toed sloth in Costa Rica.

Adult moth's streamlined body is well adapted for moving through the sloth's ;hick hair. Two moths may be seen here.

[Two-toed sloth], *Choloepus hoffmanni*, ;t right, of Panama and Costa Rica, s another host of the sloth moth.

The sloth moth does not seem to fit he definition of a true ectoparasite. ᴀs yet no stage of the moth has been ıbserved to feed on any part of the ıost. There is widespread speculation hat the larvae live on the sloth, feed- ng on the algae that so often grow bundantly on this mammal's hair, but o our knowledge no valid observation ıas confirmed this belief. Careful ex- mination of numerous sloths in Costa ℓica at different seasons of the year re- ealed no moth eggs, larvae, or pupae, ven when adults were abundant. If, in act, the larvae do live on the host, hey may feed upon the animal's hair tself or on skin debris in a manner imilar to that employed by ancestors ·f the clothes moth.

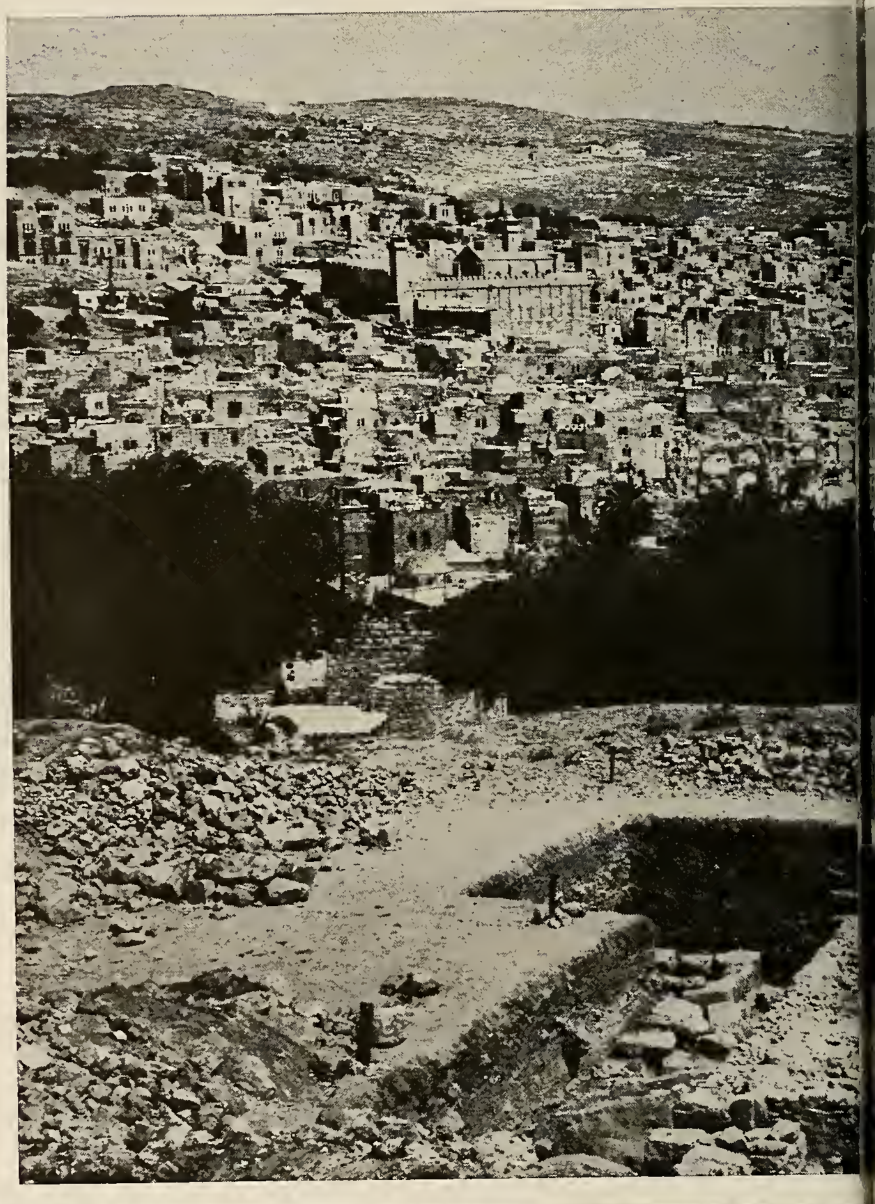
An alternate hypothesis to explain ıe presence of these moths in their nusual habitat is possible: the dense air of the mammal simply offers a nique refuge for the adult moths, and ıe larvae are normal plant feeders like most of the other members of their subfamily, Chrysauginae.

The adult moths do not appear to feed, as indicated by their reduced mouthparts. The presence of a few additional anatomical peculiarities suggests relatively recent association of these Lepidoptera with the sloths. The depressed bodies and the capelike vestiture of long scales projecting back across the head, neck, and bases of the wings are apparently adaptations to facilitate the movement of the animal through the forest of hairs in which it lives. This cape of scales may function in much the same manner as the ctenidial combs of fleas and other ectoparasitic insects. The combs are rows of backward-projecting, stout spines that help streamline the insect's body and, like the barbs of an arrow, prevent it from being drawn back through the hairs. The moths are capable of rapid and agile movement among the hairs, and fly readily about the host when disturbed, making them extremely difficult to catch.

Collecting moths from the three-toed sloth is an interesting exercise, and the truly slothful movements of the creature permit the operation to be a leisurely one. The mammal's defensive motions are confined to slow, methodical movements of its head from one side to the other. One can spend two or three minutes on each side picking through its pelt and chasing the moths with forceps. The two-toed sloth, on the other hand, is far from being an indolent creature, lashing out with its large claws and nipping ferociously when confined. To collect sloth moths from this species could be hazardous.

It would be a rewarding project to investigate the true nature of the relationship of the sloth moths to their hosts. We still need to know the structure and food habits of the larvae—as well as the reasons for the attraction of the adults to the mammal.

Ancient Hebron, the



THE hill country of ancient Judah casually rolls southward from the Sea of Galilee toward Egypt. Here and there, a few small villages momentarily interrupt the flow of the stark and rocky landscape. Some eighteen miles below modern Jerusalem, one of these interruptions has taken advantage of its five-thousand-year perch to sprawl into the rather large town of El Khalil. From an elevation of approximately twenty-six hundred feet, the town still surveys the historic trade communication line through the hills—now a dead-end road.

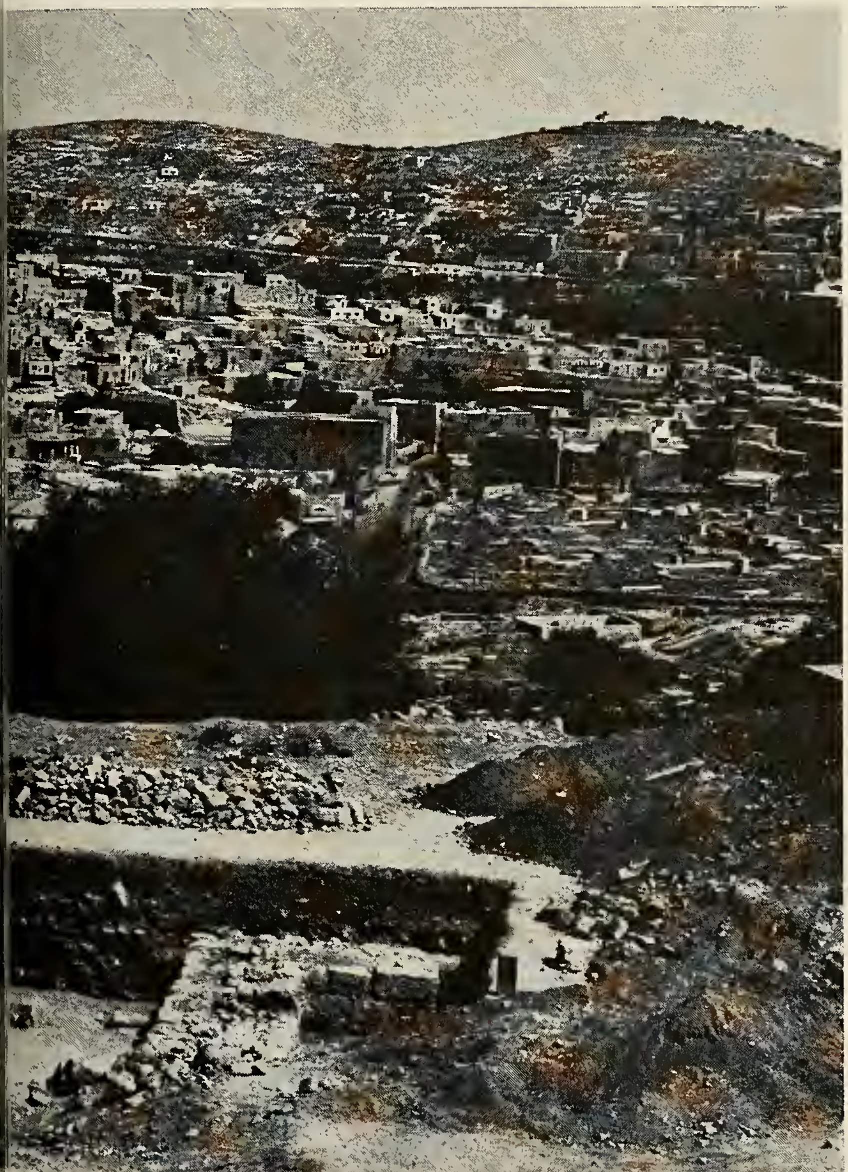
Miles of greenery surround the area, watered by over a score of springs, two huge pools, and late summer fog blown in from the Mediterranean a few miles to the west. Since ancient times the town and its neighboring hills have been renowned for their vineyards, pomegranates, figs, olives, apricots, apples, and nuts.

In the southwestern sector of the town rise the walls of an imposing mosque, the Haram Ibrahim, traditional burial place of the Patriarch Abraham and his family. Nearby are the sites of the oak of Mamre, where Abraham pitched his tent, and Ramat El Khalil, where he built his house.

The biblical name of this town was Hebron, meaning "a league" or "association"; the modern name of El Khalil means "the friend," so called in honor of Abraham, "the Friend of

City of David

By Philip C. Hammond



Excavation of an Islamic house overlooks modern El Khalil. In left background is the Mosque of Abraham, tomb of the Patriarchs.

Jebel er-Rumeide, south of the present town, may have been site of city gate. Hebron was possibly occupied in Early Bronze Age.

God." Its claim to fame—ancient and modern—is based on its situation, its agriculture, and its history. But these very factors seem to have been the town's undoing: the dead-end road beyond it stopped the flow of progress and intercultural exchange that had made it famous in the past; the richness of its agriculture became a hereditary sinecure for its sons only; its sanctity froze into fanatic orthodoxy unmatched anywhere else in Jordan. El Khalil became a byword throughout the East as a most unpleasant place for foreigners, difficult for settlement, and almost impossible for non-local businessmen.

Such was the local climate when I requested a permit from the Jordanian Department of Antiquities to excavate at Hebron. All objections to the project were met, pacified, or countered by almost two years of careful planning, close consultation with the Department of Antiquities, the assistance of other governmental offices, and oddly enough, the almost overwhelming co-operation of the local inhabitants. Specific details were discussed, in letters and in person, with Dr. 'Awni Dajani, Director of Antiquities of Jordan.

I conducted a preliminary survey on the site with the excavation secretary in 1963, in order to propose tentative areas for excavation and to meet the people of El Khalil. We visited fields, haunted municipality offices, questioned farmers and shopkeepers, and answered their endless questions in return. A thousand-meter perimeter was set around the mosque area to reassure everyone concerned with the sanctity of the holy place—Moslems, Christians, and Jews—that no desecration would take place. This was an official governmental action, and was made known to the local population.

On the evening of July 14, 1964, the project finally got under way, as the twenty-two staff members of the American Expedition to Hebron sat down to their first dinner together and their first briefing session on customs, protocol, and other niceties of Arabic life.

Cistern and drainage canal, in trench at left, were revealed during the dig.

This particular approach was perhaps more necessary at Hebron than at any other site because of the local cultural climate. As a result, the summer passed without incident or difficulty.

Hebron is one of the last major biblical cities of the Near East that had not been excavated, although it is related to critical traditions and developments during the entire period of biblical history. Said to have been built "seven years before Zoan" (a city that was in the Nile Delta of Egypt), Hebron is shown in the Bible as a thriving town in the tradition of the Patriarchs. The Patriarch Abraham is closely associated with the site in the biblical account, and may well have been a cult hero of the district whose story was assimilated into the biblical saga. In any case, the Abrahamic story of Middle Bronze Age Hittite residence in the area, plus the possibility of cultic materials from this era, warrants interest in the site. The Mosaic tradition also knows of Hebron, for it was to this place that spies were sent to reconnoiter the "promised land," after the Exodus.

In the conquest of Hebron—narrated in Joshua and Judges—the city again plays a role as one of the objectives of the invading Israelite Army, taken, "utterly destroyed," and given to Caleb, a clan follower of the Israelites, as an inheritance. Samson, that legendary prankster of the period, contributed to Hebron's fame by carting there the front gates of Gaza, on the western coast, during a fit of pique against the Philistines. Hebron, under the control of the Levites, was also one of the cities of refuge, where fleeing killers could find sanctuary.

But it was under the Israelite monarchy that Hebron's reputation was made historically. With the death of Saul and the fall of his army to the Philistines, David suddenly returned from a mercenary career with that people and was made king over Judah at Hebron. The city remained David's capital until he took Jerusalem seven and a half years later. Of the events of that time the Bible says little, yet during this period the Davidic political structure evolved, along with the religious cult and the theological orientation of Israel.

With the shift of the capital city to Jerusalem, Hebron was eclipsed politically. Yet the ancient claims of the city's greatness were recognized by Absalom, David's son, who attempted to usurp his father's throne and be proclaimed king at Hebron. He was thwarted, and Hebron emerges in the Old Testament as one of the fortified cities of Rehoboam, Solomon's son.

The possibility that the site was a Canaanite royal city, with nearby Mamre as a cult and oracular shrine, seems quite definitely indicated by its inclusion in the biblical sagas. By the fourteenth century B.C., the Amarna letters, written by petty officials in Palestine to their Egyptian overlord Ikhnaton, refer to a city that seems to be Hebron. Likewise, the Medinet Habu conquest list of Ramses III mentions a site that might be that city. The eighth century B.C. knew Hebron as a pottery works, as is attested by inscribed jar handles found throughout Palestine.

After the fall of Jerusalem in 586 B.C., Edomites from the desert moved in and occupied Hebron, and were not driven out until the days of Judas Maccabaeus. In about 164 B.C., Judas took the city from the Idumeans and pulled down its fortifications.

In the days of Herod the Great Hebron again emerged, refurbished

d honored as part of that king's ex-
ısive building operations. An en-
›sure was built around the tradi-
ınal site of the cave of Machpelah,
ɛ burial place of the Patriarchs,
›ng with other civic betterment proj-
ts still discernible by their character-
ic masonry. In the latter part of the
cond century A.D., Hadrian built a
ad to Hebron and established a
ırket that became renowned. Con-
ıntine kept up the architectural
cord of his predecessors, and built
basilica to the memory of the Patri-
chs in the fourth century A.D.

When Islam erupted from the Ara-
ın peninsula, Hebron's ancient re-
;ious fame was again recognized.
ıe city and its fields were given by
ɛ Prophet Mohammed to the Tamin
-Dari and their families, and the
ve of Machpelah became a mosque.
ıe site formally entered its first
amic period (*ca.* A.D. 635–1200)
d became a major Moslem holy
ace in Palestine.

During the Crusades, Hebron was
ptured and refortified as the "Castle
St. Abraham." For a time this was
ɛ southernmost point in the Latin
ngdom's defenses, a fief of Gerard
Avennes, under the patent of God-
ey of Bouillon. In A.D. 1167, Chris-
nity gave way once more to Islam.
1210, Moslem control was firmly
ablished over all the area, and He-
on became a station on the hegira
ute to Mecca.

With the beginning of scientific Near Eastern archeology in the early years of the present century—and more particularly since the mid-thirties—biblical and historical sites in Palestine were excavated one after the other. Only excavation at Hebron was never attempted. Thus, in the summer of 1964, scholars were granted the unique opportunity of excavating at a completely untouched site of major historical importance.

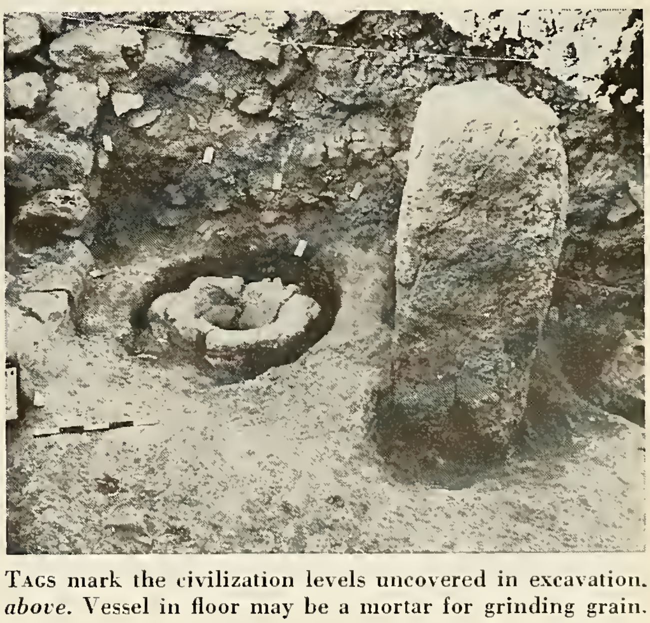
Excavation at Hebron followed the methodology developed by Sir Mortimer Wheeler and Dr. Kathleen Kenyon, generally referred to as "stratigraphic." The presupposition of this technique is that every period of human occupation (or lack of it) in an area leaves some discernible trace that can be isolated. Hence extreme care is taken in excavating a limited field or area, stratum by stratum.

At Hebron, we selected three major areas. Area I was the mountain known as Jebel er-Rumeide, to the south of the modern city, today largely given over to olive groves. Area II was a field at the crossroad of the two main arterial communication lines at the northwest end of the modern town, in the valley called Wadi Tuffah ("the Valley of Apples"). Area III was on the eastern slope of Jebel Batraq ("Mountain of the Patriarch"), to the north, an area of modern vineyards.

Areas II and III were investigated by soundings only—these were usually 16-foot-square excavations, dug only as a test. This was done in an effort to check the extent of habitation in antiquity at those points. Unfortunately, both produced negative evidence and were closed. Area I, however, seemed most promising during the preliminary survey, and justified that promise upon excavation.

Site 1 of that area was first opened on a terrace step in the midst of an olive grove, against an existing, ancient wall line still visible on the surface. This was the highest trench site on the mound, and was thus presumed to have been inside any defense works erected around it. Excavation proved this evaluation correct.

Dr. Murray Newman of Virginia Theological Seminary and Dr. Robert Boyd of Luther Theological Seminary acted, in turn, as supervisors of this site, with the assistance of student members of the staff. Less than half a meter below modern surface (terracing fill), the excavators began to strike results. Some 97 levels and 19 phases later, the first trench had more than justified the problems resulting from blocking traffic across the grove, dodging olive tree roots in progress, and moving out rock fill (*page 46*). On bedrock itself were the remains of what appeared to be a mud-brick structural wall. Its destruction by subsequent building operations in later periods precluded much in the way of plan, but the remnant of the structure



TAGS mark the civilization levels uncovered in excavation, *above.* Vessel in floor may be a mortar for grinding grain.

ROOF PILLAR, *left,* was discovered still erect on the plaster floor; once it may have supported the house's second floor.

RECTANGULAR blocks in pavement are dated from the Byzantine Empire.

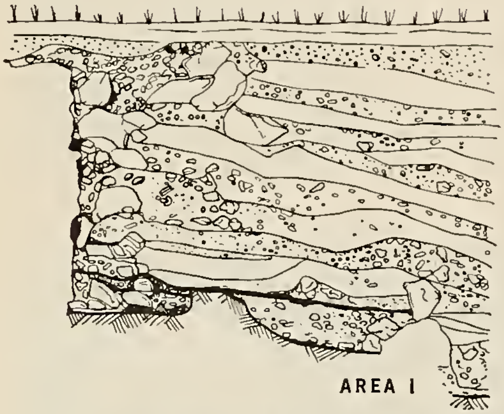
(probably a house wall) at least gave evidence of occupation at this point and in this area as early as the beginning of the Early Bronze Age I in Palestine (*ca.* 3100–2900 B.C.).

After a long period of abandonment, the area was filled and built up with a combination of bricklike levels of clay, soil, and soft limestone, with a plaster floor. The Middle Bronze Age I (*ca.* 2100–1850 B.C.) had been reached by this point, and building operations continued rapidly through both the transitional stage of that period and its more specific divisions. A rather heavy wall of stone was next encountered, cutting into the earlier structures and going down to bedrock. Fragments of a thick, yellow clay plaster, typical of the site as a whole, were found on the interior side of the wall.

Apparently the later part of the Middle Bronze Age saw some change in the habitation of this quarter of the mound, for two burials were uncovered, cutting through floor levels of the wall stage, and marked by stones—hardly what one would expect within the occupied area of a Middle Bronze Age town, where external necropolises were the practice. These two burials were unaccompanied by any of the usual burial goods associated with tomb burials, with the exception, happily, of pottery. Following this phase of use of the area, a succession of poor floor levels, some showing the fire marks of camping, continues on all through the latter part of the Middle Bronze Age.

A gap between the end of Middle Bronze Age and the Iron Age appears at this point, although a few Iron Age I sherds (*ca.* 1200–900 B.C.) mixe with later ones indicate some occupa tion of Jebel er-Rumeide during tha time. It was the Iron II period, fron about 900 to 587 B.C., that provide the expedition with a fine house plar however. Although existing olive tree prevented securing the entire plar sufficient evidence regarding its natur was possible. Within the walls th house boasted a thick floor of the sam ubiquitous yellow clay found in th Middle Bronze Age structure. Sun into the floor was a large mortar an a monolithic pillar. The latter prob ably served to support the second floo of the house, since by Iron Age II th Israelites, who had now taken ove Canaan and were well settled, ha moved up to the second floor level c their dwellings, leaving the groun floor for their animals. Storage jar one complete and intact, were foun here and there inside and outside th house walls. The complete specime was found sunk under the floor, i mouth at floor level. This type c "pantry" was not unusual and can b traced from Early Bronze times.

Another gap appeared in the chro



DIAGRAM, *above*, and photograph, *right*, show some of the 97 levels of the first trench. Early Bronze Age habitation is traced to the lowest level in trench.

VESSEL dating from the Late Bronze Age was found in lowest trench level.

logical sequence, following the sec-
nd part of the Iron Age phase.
ometime in the Late Roman-Early
yzantine period, between the late first
entury A.D. and the middle of the
ourth century A.D., this particular area
as again the site for building opera-
ons. Considerable fill was poured
ver the existing ruins, and on it was
id a pavement of heavy slabs.

Slightly lower down Jebel er-Ru-
neide, on a broad terrace not compli-
ated either by modern cultivation or
rchards, surface pottery indicated the
robability of fairly heavy occupation
n the Islamic period. Dr. R. Coleman,
f Southwestern Baptist Theological
eminary, opened a five-meter square
n the center of the field. This site soon
roadened, as the walls and rooms of
n Islamic house of early date began to
merge just under the surface on the
nderlying bedrock. The house's ar-
angements of walls, patching, relay-
ng of floors, and pottery remains indi-
ated a long period of use. It soon
ecame obvious to us that here was a
esidence of some size and richness.
his fact, coupled with a clear view
cross the valley to the city and the
osque, suggests that this was the
ome of a prominent citizen of Hebron
n the early Islamic period.

By the time excavation was com-
leted, over a hundred strata with ten
hases of occupation were discernible.
f these phases, four related to the
slamic house directly. The earliest
age of the house's use was clearly its
ost important, for in succeeding
ears, the exterior levels built up
apidly, crosswalls marred the plan,
nd rather poor attempts were made at
epairs, showing a steady decrease in
e fortunes of the tenants. Originally
e house boasted colorful plastered
ooms, a large bath tiled in small mo-
aics, an outdoor cooking area, well-
id drains, and a large storage cistern
ut into bedrock for storage of water.

THE change of fortunes of other residents of the site also appeared
uring the excavation. Most notable
as a capital, quite obviously "ac-
uired" from a Byzantine church lo-
ated a few hundred meters away. The
uilder of the house had used the
apital as a stepstone, but so his choice
ould not offend fellow religionists,
e carefully plastered over the crosses
nd flanking doves that were carved
nto the four sides of the capital's
ectangular top.

ONE of the two Bronze Age burials is seen as discovered under an Iron Age house level. This was unusual in an area that had external necropolises.

Beneath the floor of one of the side rooms, a Byzantine period burial was also uncovered. This was a secondary interment, with the bones rearranged inside a wooden casket. The wood had totally disintegrated, but large iron spikes still held its shadowy outline together in the surrounding soil. Remnants of still earlier periods also came to light below the house, going back to the same early periods found elsewhere on the site. Coins, glass, objects of everyday use, sherds, and one complete vessel about twelve inches wide, formed with three compartments, came out of the debris of this house.

One trench, under the supervision of Dr. Gerald A. Larue, of the University of Southern California, proved to be the most significant in terms of the ancient fortifications for one of the Near East's most militant periods, the Hyksos age (*see* NATURAL HISTORY, August-September, 1963). At surface level, in front of the remains of the massive vertical wall, a fifteen-foot addition was found; both walls were firmly set on and in bedrock. Floor levels and their associated pottery indicate that the extension to the main wall was of Hyksos period origin, and may reflect a local version of the plastered scarp technique found in Hyksos fortifications elsewhere.

The lowest levels produced materials seen elsewhere on the site and dating from Hebron's earliest periods. An Early Bronze I complex was found, consisting of deep pits cut into bedrock, with a plaster slab and walls. Miscellaneous sherds dating from about 3600 to 3100 B.C. were also recovered, but without any structural features associated with them.

The possible presence of a gate area a few hundred yards from this site suggests that Jebel er-Rumeide was inhabited thickly enough during the Middle Bronze Age, especially *ca.* 1750–1550 B.C., to warrant the erection of the complex wall system.

IN order to investigate both the possible continuation of the wall of the third trench and the wall lines of the first one, still another trench was opened. Under the supervision of Mr. James Herrington, of Princeton Theological Seminary, this excavation produced one of the "busiest" complexes of walls on the mound. The main set of the ten walls uncovered here was related neither to the Middle Bronze Age walls, nor to the Iron Age complex, but, rather, to the Islamic house. The same process of overbuilding and rearranging became obvious, paralleling the progressive stages of plan modification seen in the house.

Below the Islamic walls were the truncated fragments of earlier wall lines, but little was left after the Islamic builders sank their foundations. At the bottom of the trench, however, the fragments of a single, large vessel from Late Chalcolithic–Early Bronze times (*ca.* 3260–3100 B.C.) were recovered, as well as quantities of the Early Bronze painted ware.

While these operations were going on, three student members of the staff sought out Hebron's ancient tombs. The first test was conducted by Mr. Frank Garcia, an Arabic-speaking graduate student from Princeton Seminary. Not far from the site of the Islamic house, modern treasure hunters had begun operations that seemed to promise results. A sounding was made at the top of a terrace slope,

SHERDS are examined and dated, *above*, in "pottery session" by staff.

TRIPLE-COMPARTMENT VESSEL, *left*, is unique; it dates from Islamic period.

CERAMIC seal, *below*, has geometric design. It is $1\frac{1}{2}$ inches in diameter.

and what appeared to be an underground opening was reached after going down through a considerable mass of terrace fill, including Late Roman and Byzantine debris. It was then decided to approach the opening from the side of the slope, to expedite the removal of the fill. Instead of an opening, however, the workmen uncovered the remains of a vaulted structure with related walls, resting on a bedrock ledge. Below the ledge, at some depth, two openings in bedrock were found. These appear to be tunnels, and may be related to similar subterranean passages found elsewhere on the site. Because of the nature of the fill, the size of rockfall in the entries, and other factors, however, these passages could not be cleared and explored in the 1964 season.

As the rockfall was removed from the ledge, connection was made with the sounding square originally made at the site. The opening that had been reached from above proved to be through the top of a crude dome over the mouth of a cave. When the masonry complex was cleared, photographed, and surveyed, entrance was gained by the removal of the dome. Inside was a fairly large cave, heavily silted and encumbered with fall debris. Fire marks and other evidences showed this to have been a residential cave. When the occupation period was finally reached, another complete Late Chalcolithic bowl was discovered, lying up-ended upon a platform-like earthen and stone bench at one side of the cave. Although not a tomb, this complex, especially the cave proper, furnished further data concerning occupation on the site. It gave the first positive evidence of actual habitation (as compared to casual camping), during the later part of the Chalcolithic period, of Jebel er-Rumeide, itself.

A tomb test in an olive orchard at the southeastern end of the mound, and well down the slope, also seemed promising. Its location was ideal for a necropolis hunt, and the magnetometer survey indicated considerable subsurface disturbances. All of this "evidence" resulted in a five-meter square of gently sloping bedrock, less than two feet beneath the surface! A "dog-leg" sounding trench at one corner resulted in a wall line, one stone high, resting solidly on bedrock. We decided to give up, and go to a more productive area. On the day that excavations were to be halted on the site, however, we found that the surface of bedrock dropped sharply, disclosing a vertica[l] face and the mouth of a cave that wa[s] clogged with fall debris. When the cave was excavated, level by level, anothe[r] early "residence" had been added t[o] the expedition's notebooks. Three sep[-] arate phases of occupation were iso[-] lated, with complete pieces of potter[y] found lying on the surface of the high[-] est floor level, exactly as they had bee[n] left when the inhabitants had fled thei[r] cave home during an earthquake.

The pottery from this cave site wa[s] almost entirely Early Bronze I in dat[e] with some probably Late Chalcolithi[c] sherds at the lowest levels. Hence, onc[e] again, positive evidence of occupatio[n] of Jebel er-Rumeide had been foun[d] for a definite chronological perio[d]. Still further, the nature of the Earl[y] Bronze pottery, and its connection wit[h] Late Chalcolithic sherds and forms, i[n-] dicates that the transition between th[e] two periods was chronological, n[ot] cultural. This information was also [of] value in sorting out the intercultur[al] flows of the southern sector of Pale[s-] tine in early times, as related to the[se] two periods.

SOME eight months before the exp[e-] dition arrived, on another site a[n] enterprising homeowner decided, u[n-] fortunately, to dig a basement. In th[e] process, he cut into a tomb cavern[-] and cleared it out himself. Local rum[or] suggested that more than five thousan[d] pieces of pottery, scarabs, metal o[b-] jects, and other artifacts had bee[n] found—and sold as antiquities.

On the long chance that anoth[er]

tomb chamber had been missed during the illicit digging, a team of excavators went to work in the excavated chamber. Hewn out of bedrock, with a central pillar supporting its roof, the room appears to have had a long history of use. More than twenty-three burials were represented in the skull fragments recovered from the dump of the pillagers, as well as a fair quantity of the representative pottery that had been interred. The illegal excavators had simply discarded sherds and damaged pieces, for which there was no market, leaving the expedition with at least good evidence of the period involved. Yet this discouraging situation was not without a brighter side. Where one tomb is found, the probability of others exists, and a survey in the householder's tomato fields bore this out.

During the summer of 1965, a smaller expedition was formed to conduct an "interim season" at Hebron. The purpose of this expedition was mainly exploratory, in preparation for the next full season in 1966. A trench adjacent to the Islamic house of the 1964 season was opened in order to secure further data concerning that structure. Instead, a Byzantine cemetery was brought to light, whose full extent will be followed up next season. Another trench, near the great Hyksos wall, also disclosed Byzantine remains cut into bedrock. A fourth test proved to be another house-cave, reused during the Hyksos period for burials. Seven burials were represented, with over 165 complete pottery vessels. Most important of all, however, was a "warrior" burial, complete with a bronze dagger. A tomb below a recently constructed house had already been cleared, but in the untouched entryway about 50 vessels were recovered, dating from the early part of the Iron Age. Almost a mile of magnetometer survey was carried out, to clarify the subsurface outlines as a guide to future excavation.

Plans are now under way for approximately eight seasons of full-scale excavation at Hebron. Each season will contribute more data, and eventually the complete story of the city's history and culture will be pieced together from its stratigraphy, its artifacts, and the analysis of its buried remains. Not least among the possible answers to be given is the riddle of the establishment of the Davidic monarchy and its written records, in addition to more light on the complex cultural flow in southern Syro-Palestine at the very dawn of human existence.

Tomb chamber, with supporting pillar, was cut into bedrock; the remains of 24 burials were found, dumped here in illicit digging by modern householders.

SOLITARY white flowers bloom only for a day, giving rise to large fruits whose pulp and seeds are edible.

The African Baobab

By IAN MICHAEL WRIGHT and OLIVER KERFOOT

No tree gives so vivid an impression of the vastness, variety, and magnificence of Africa as does the baobab. These grotesque and unwieldy trees have become an integral part of African history and legend, and their unnatural appearance figures prominently in a number of weird tales.

The baobab, *Adansonia digitata,* is a member of the family Bombacaceae, which includes balsa, the kapok tree, and several other species of economic value, many of which have similarly thick trunks. It is named after Michel Adanson, a French philosopher-explorer-naturalist, who wrote from Senegal in 1754: "I perceived a tree of prodigious thickness which drew my whole attention . . . I do not believe the like was ever seen in any part of the world." Baobabs have numerous local names, among them the Ethiopian sour gourd tree, cream-of-tartar tree (its fruit has a slightly acid taste), monkey bread tree, *tebeldi* (Arabic), and *mbuyu* (Swahili).

Although baobabs are not exceptionally tall, their trunks are often enormous. One in Tanzania has a circumference greater than 130 feet. Their smooth, heavily folded bark is pinkish gray or coppery in color, and at a distance resembles the wrinkled skin of an elephant. At the top of the trunk there is often a natural basin that fills with water during the rainy season. These elevated reservoirs support large populations of malarial mosquitoes and also provide a ready source of water for thirsty travelers. During the era of slave trading, baobabs marked important campsites for travelers who had to cross the waterless terrai

In East Africa the baobab's fir green leaves normally appear durir October, and with them beautiful whi blossoms, solitary and pendulous, wi dozens of delicate filaments surroun ed by five waxy petals. These have n scent, but when bruised they emit a objectionable odor, vaguely resei bling putrefying meat, that is attra tive to carrion flies. The gourdlil fruit, known as monkey bread, ma appear as early as December and ca be seen as late as August. It consists a large, woody capsule with a ha shell up to twelve inches long, contai ing a mucilaginous pulp in which t seeds are buried. Young trees yie some fruit after eight or ten years, b produce abundantly only after thirt

The distribution of the baobab irregular. Essentially a native of tro ical Africa, it is found as far north

Baobabs have weirdly shaped branches. David Livingstone once referred to the tree as a "carrot planted upside down."

)bject of Awe

Kordofan region of the Sudan, and far south as the low veld of the ınsvaal in the Republic of South ica. It has an uneven distribution the west coast of Africa, and a sely related species occurs in Madscar. It is common in most coastal l thornbush areas of East Africa at tudes below 5,000 feet but, strangenough, is not found in Uganda. In tral Africa it thrives only below)0 feet, being generally restricted he hot, low-lying river valleys in as of scant or erratic rainfall. Ocional trees, however, have been seen he upper reaches of the Luangwa er of Zambia, where more than y inches of annual rainfall have uently been recorded.

lthough baobabs were known to opeans as early as 1592, they have n objects of worship in African lition from time immemorial. In Southern Rhodesia the baobab is the totem of the Sebola clan of the Twamumba tribe. There the clansmen offer prayers to the tree and believe that their ancestors lived almost exclusively on its fruit. Quite possibly they did—for virtually everything in the baobab is used somewhere for something. Even its soft and spongy wood can be pounded into a fiber suitable for ropes or floor mats. It quickly rots, however, and the Hausa of Nigeria call it *fanko,* which means "good-for-nothing."

Much of the tree can be eaten, in one form or another, usually as a seasoning or appetizer. In times of scarcity it becomes a staple. The fruit's pleasant, cool-tasting, acidic pulp and black seeds are both edible. The pulp is refreshing either raw or mixed with water and boiled. and the seeds are pleasant to suck. When ground they make a passable substitute for coffee. But among the Ila people in Zambia they are taboo. Anyone eating them supposedly runs the risk of being bitten by a crocodile.

There is abundant food value in the baobab's vitamin-rich leaves, which resemble spinach, and the tender roots of young baobabs are similar to asparagus. Cattle and horses benefit, too. In Nigeria the leaves are a usual ingredient of fodder, and give horses the energy for long and arduous trips.

Native doctors prescribe specific mixtures of the baobab plant for almost any ailment. from smallpox and toothache to kidney trouble. Roots, leaves, fruit pulp, and bark are all utilized medicinally. A concoction made from the leaves is used as a cure for dysentery and respiratory ailments and is frequently administered as a prophylactic against fevers. The bark

sometimes serves as a substitute for quinine. In fact, although the baobab does not appear in any of the modern pharmacopoeiae its medicinal qualities were once so famous that the Sudan exported the various components to Europe.

Baobabs have numerous domestic uses as well. A red dye is extracted from the roots, and its seeds make good fertilizer and fuel when finely ground. Ash from the burned seeds is used to make both native soap and plaster for the walls of huts. The hard shell of the fruit can be made into a receptacle for carrying liquids or snuff and, pulverized, is an essential ingredient of snuff itself. When the fruit pulp is burned, it emits clouds of irritating smoke that act as a fumigant to keep cattle free from biting insects. Finally, Africans can even extract a strong glue from the accumulated pollen grains of the tree's flowers.

The tree's greatest value, however, lies in its bark. In the Cameroons, it is used for tanning. Waterproof hats and drinking cups, as well as beer strainers, those indispensable domestic utensils, are made from the fiber of the inner bark. It is also used in ropes and in strings for musical instruments, and can be woven into a bark cloth for clothing. At one time it was exported to England for the manufacture of strong packing paper.

Fortunately, the vitality of these trees is amazing, and somehow they survive the repeated stripping of their bark. They seem to have the cork tree's power of regeneration. Even when their interiors have been burned out, they still flourish. Enormous populations of wild bees frequently inhabit such hollow trees, and natives use them widely for the suspension of beehives.

Some tribes are known to carve homes out of the boles of living trees. In one town a waiting room at a bus stop is a hollow baobab that can accommodate thirty people with ease. In still another town, a baobab houses a bar containing both counter and stools. In the Sudan, baobabs are used as water cisterns, for as there is little evaporation the water remains sweet and clear throughout the dry season. The trees also make good drying chambers in which suspended bodies can be conveniently mummified.

In central Africa, some tribes believe that Resa, the Rain Lord, lives high in the sky in a baobab that was said to be the roof of the world. Some of these tribes believe that there are no young baobabs, but that the huge adults simply appear full grown. This myth is not so unreasonable as it may seem, for the young plants are stately and slim by comparison with their bulbous elders—although, of course, they have the same foliage characteristics.

There is a Bushman legend that when the first spirit granted trees to the members of an early race, he gave everyone something to plant. But when the lowly hyena, the force of evil, arrived, there was only one tree left. The hyena upbraided him, saying "Are you surprised I behave so badly when you treat me differently from other cre tures?" The spirit gave him the la plant, a baobab, and out of spite tl hyena planted it upside down. Indee its contorted branches do look lil roots; David Livingstone, in a ra touch of humor in his otherwise sei ous journals, described a baob somewhat unkindly as "a carr planted upside down." As is often tl case with tribal legends, there is grain of reason behind this upsid downism, for the roots of these tre spread out laterally for a hundr yards or so just below the surface, e abling them to tap sources of moistu otherwise unavailable.

The life-span of baobabs is un-
:nown, for their wood shows no an-
ıual growth rings, but modern botani-
:al research rejects any theories of
'ast age. Nevertheless, the trees are so
nuch a part of this strange continent
hat they seem inevitable and inde-
tructible. Unfortunately, each tree's
ıltimate fate is oblivion. There is no
najestic crashing down of a forest
iant to remain in slow, still-vitalized
lecay on earth. There is only a crum-
oling subsidence, which in time forms
soft mound of bleached, powdery
ragments that will be scattered by the
vinds and devoured by termites until
othing of the tree remains.

Trunks of heavily folded bark are enormous, often 30 feet in diameter.

Basin at top of the trunk often fills with water and acts as a reservoir.

ANIMALS FROM THE ROUGH

Stones are carved and polished in an Old World tradition

photographs by LEE BOLTIN

The search for, and discovery of, an animal form within rough and variously shaped blocks of precious and semiprecious stones is the artistic odyssey of West German sculptor and engraver George O. Wild. Born in Idar-Oberstein, the famous gem-polishing center of Europe, he continues a family tradition in a craft that dates back at least to the work of his great-grandfather, an artisan in czarist Russia late in the eighteenth century.

The color, shape, and texture of a rough stone—as well, of course, as its availability—are central considerations of Mr. Wild's art. He travels throughout Germany, and on one

occasion visited India, to collect stones that might be suitable to his work. Nor is collection always a simple matter. While working on his "Birds of America" series in December, 1956—which was shown at the Academy of Natural Sciences of Philadelphia and at F. J. Cooper, Inc., Philadelphia jewelers, in 1963—Mr. Wild needed jasper for several contemplated bird figures. He finally located deposits in the western region of Germany, but the ground was frozen, and he was forced to wait until spring. Even then he had to open the pits and mine the jasper himself since it was no longer mined or marketed in Germany.

The owl, as well as the base on which it rests, is made of a silica known as jasper.

: uneven translucency of agate is used to ticular advantage in the moose, left.

The ferocity of the black obsidian boar is emphasized by gleaming chalcedony tusks.

Carved out of jasper, the sandpiper has onyx eyes. Legs are oxidized sterling silver.

Impurities are often found in jasper and here serve to show the frog's skin markings.

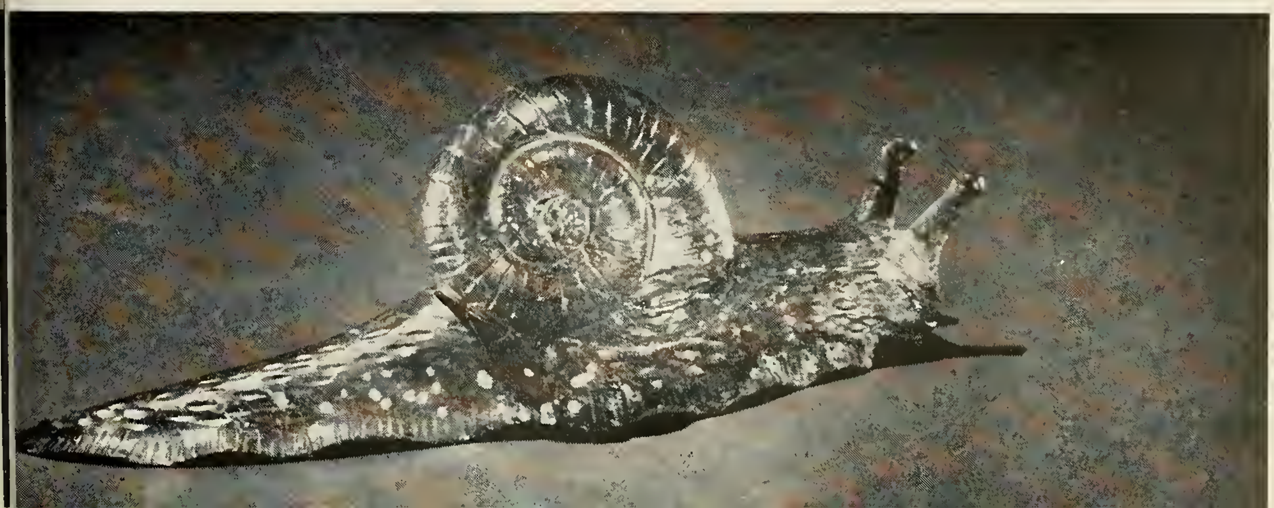
The process by which Mr. Wild decides what to do with a piece of stone is best left to his own description:

"I am now [1963] working on an owl of aragonite. I had the stone in my yard for two years and it never spoke to me. The other day it cried out 'owl, owl, owl,' and I believe that the animal will turn out well. Why a stone is mute for years and then speaks is beyond me. Some stones, however, induce me to work on them immediately. Others have different vagaries. A week ago I saw an agate that, so I thought, would lend itself for a large pike. When I finished roughing it, it turned into a whale."

These fish, two individual carvings, were fashioned from delicately banded agate.

Green verdite quetzals, left, with wings and beaks of jasper, perch on quartz geode.

Carved from a decorative lapis lazuli, the snail seems to be inching its way along.



About the Authors

Dr. Joan Mencher, author of "Namboodiri Brahmans of Kerala," is presently a Research Associate in Anthropology at Columbia University. She has worked mainly in Kerala and Madras, the two southernmost states in India. Her study of the Nayars and the Namboodiris extended from 1958 to 1962, and involved 26 months of field work. Her contributions to scholarly journals have emphasized the role of social structure in the changing Indian scene.

The author of the article on rhesus monkeys, Dr. John G. Vandenbergh, has been a Research Scientist with the North Carolina Department of Mental Health since September, 1965. Before then, he worked at the National Institute of Neurological Diseases and Blindness in Puerto Rico. It was on the islands off La Parguera in Puerto Rico that Dr. Vandenbergh first studied free-ranging colonies of rhesus monkeys.

"The Man-o'-War Bird" was written by Dr. Bryan Nelson, who is a Research Fellow in zoology at Aberdeen University in Scotland. A past visitor to the Galápagos Islands, Dr. Nelson will shortly embark on an ornithological research trip to Christmas Island. He is especially interested in the behavior and ecology of boobies and gannets and of sea birds in general.

Dr. Charles L. Hogue, coauthor of "Hideaway for Moths," has been Curator of Entomology at the Los Angeles County Museum of Natural History since 1962. He works particularly on the biology and taxonomy of moths and primitive flies. His collaborator, Richard Casebeer, is a candidate for a doctoral degree in the biological sciences from the University of Southern California. He now acts as a consultant to the Biological Sciences Curriculum Study.

Dr. Philip C. Hammond, a noted Near Eastern archeologist, is Assistant Professor in Old Testament at Princeton Theological Seminary. His article "Ancient Hebron, the City of David" is based on the findings of the American Expedition to Hebron, which he heads. Dr. Hammond is a frequent contributor to religious and archeological journals.

Ian Michael Wright, currently Program Officer of the African-American Institute in Washington, has worked and traveled in Europe, Japan, the Middle East, and Africa. He confesses to having been intrigued with baobab trees since childhood, when he read about them in Antoine de Saint Exupéry's tale *The Little Prince*. His coauthor, Oliver Kerfoot, now Research Silviculturist at the East African Agricultural and Forestry Research Organization in Kenya, has for many years been a student of plant ecology and the migration and distribution of the African flora.

Mounting diatom slides

By Julian D. Corrington

DIATOMS are unicellular, microscopic plants occurring, singly or in colo- es, in immense numbers in both salt .d fresh water over all the earth. They e, and long have been, of great interest students of the microworld and to llectors, hobbyists, and mounters of icroscope slides.

The cells are enclosed in a "glass use" of silica known as a frustule. The ustule is composed of two parts called lves, one of which, slightly larger, erlaps the other.

Silicon dioxide, or silica, is found in st amounts in crystalline form as artz. Quartz makes up the bulk of the orld's sand and is the chief ingredient commercial glass. Certain organisms liatoms, radiolaria, the glass sponges, d a few others—extract silica from ice solutions in water.

Where does one search for diatoms d how are they collected? Many spe- s are bottom dwellers, covering the id, rocks, pilings, larger algae, corals, d shells. These, and also the stems of uatic plants, may be scraped gently, d the scrapings placed in a vessel of ter. Other species occur as a principal n of plankton, both fresh water and rine, and these can be collected in a nkton net of fine bolting silk towed wly behind a motorboat and kept at, just below, the surface.

'ossil forms comprise diatomaceous th, or kieselguhr. Great deposits of tomaceous earth are found in many ts of the world, notably in Hungary, ssia, Japan, and New Zealand and, he United States, in California, Mary- d, and Virginia. One investigator culated that the silica shells of as ny as forty million diatoms were com- ssed into a single cubic inch of this th. One bed, in Lompoc, California, ers 12 square miles and is estimated e up to 3,000 feet deep.

ach year industry uses a quarter mil- tons of diatomaceous earth as mild asives, absorbents, filters, insulators, aggregates. Its value depends on ral inherent properties. Silica is l-nigh indestructible chemically; only rofluoric among the many acids will ck it. Diatomaceous earth is highly ous and absorbent. The minute shells as a very fine abrasive and also, like s, as a non-conductor.

here are other uses for diatoms that ern species still living. They can e to demonstrate the quality of micro- e objectives of the higher powers and resolution, for they provide a specimen that has a repeated pattern of exceedingly fine markings, which can be used as a test object for demonstrating resolving power. Certain species of diatoms have long been favored for this technical purpose. They have rows of dots of such unbelievably small dimensions and so closely spaced that under ordinary magnification the dots run together and appear as a fine line or groove. It requires a carefully manufactured and highly corrected oil-immersion objective with a high-numerical aperture, properly used and illuminated, to resolve these dots, and so such diatoms are known as test objects.

Of greatest fundamental importance, however, is the role played by diatoms in food cycles of the animal world. A high percentage of the plankton in both fresh and salt waters is made up of diatoms. With this plankton begins the food chain that supports the fish and mammals of the sea.

These are all reasons why we should study diatoms. There remains another and entirely different aspect of this subject: amateur microscopists have, in the past — especially in Great Britain — become so fascinated with the collecting, cleaning, mounting, and arranging of specimens as to have earned the sobriquet of "diatomaniacs." This is a hobby that provides an educational, satisfying, and rewarding outlet. The arranging of diatoms in pattern slides is the finest example of the mounter's art and requires experience, skill, and patience.

Preparing Living Diatoms

LIVING diatoms may be killed, fixed, stained, and mounted—as you might handle other algae.

The material as collected will be mixed with mud, sand, plant debris, and other unwanted substances, so that cleaning is the first step. In the field, the collections are placed in a jar of the water in which they occurred. When you are back at your work place, strain this material through coarse muslin to remove the larger particles. Then put this mixture (the filtrate) into a jar of clean water. Decant most of the water to carry off the fine debris. Next, in a darkened area, place the jar under a faucet with a very gently running stream to flush for at least 12 hours. The stream must be so gentle that the larger diatoms are not carried off in the effluent. (Of course, the use of faucet water is likely to introduce diatoms that are not found in the area your sample came from, but the

purpose of this article is to get an amateur diatomist started, and not to instruct him in scientific laboratory procedure.) Finally. the water in the jar should appear perfectly clear of debris, with a fine sediment, mostly of diatoms, on the bottom. Stand the jar in daylight for 6 hours, whereupon the living diatoms will gather on top of the sediment as they migrate toward the light.

Locality strew shows diatoms at random.

Remove some with a pipette and transfer them to a vial of chromacetic acid for fixing: chromic acid, 1 gm.; glacial acetic acid, 3 cc.; and water, 100 cc. Use at least 100 cc. of this mixture and fix for 24-48 hours, then wash with a very gently running stream of water, as before, for 24 hours. Use faucet water with diatoms collected from fresh water. If you have the necessary equipment and facilities, use sea water for marine specimens, both in making up the chromacetic acid and for the cleaning and washing procedures; if this is not possible, it would be better to use only fresh-water diatoms.

Stain with hematoxylin or, if preferred, any of the familiar aniline dyes. Dehydrate with two changes of dioxan, and mount in balsam or one of the synthetic neutral resins. Because air may be trapped inside the valves. it is best to use a dilute mountant, which is then gradually concentrated through evaporation of the solvent. Dissolve the mounting medium in dioxan if that method of dehydration is used, or in xylene if the alcohol series is employed. Use an excess of mountant, since it is to be concentrated, and cover the slide with an inverted finger bowl to exclude dust.

Diatoms prepared in this manner take their place in the slide collections along with numerous other unicellular algae, chiefly of interest to the botanist.

Preparation of Diatom-shell Slides

ANOTHER procedure dispenses with the living material altogether and presents only the empty shells.

The collected diatoms are given the preliminary washing already described, the final rinsing best performed in a test tube. If the remainder of the work is to be done at some future time, decant the bulk of the last rinsing water carefully in order to leave the sediment of diatoms in the bottom of the tube; then add 5 per cent formalin to kill and preserve the specimens.

When ready to proceed, wash out the formalin, decant the last of the rinsing water, and add strong hydrochloric acid to about one-fourth the depth of the tube and boil gently over a low flame. If effervescence occurs, keep adding more acid, slowly boiling it away until no further effervescence is noted. Wash thoroughly in several changes of filtered water by filling the tube, allowing the diatoms to settle, then decanting carefully. Next boil in nitric acid, wash with several changes of filtered water, and finally boil in fresh sulphuric acid. While still hot, pour into an open vessel, such as a porcelain evaporating dish, and add a few small crystals of potassium chlorate. This will produce a violent effervescence and must be done slowly and cautiously. Continue adding chlorate until the effervescing ceases, then wash in several changes of filtered water. Now the cleaning procedure is finished.

The hydrochloric acid kills the plants if this has not been done before, and removes any calcium salts that are likely to be present. The other acids remove organic matter, and the potassium chlorate bleaches. None of these strong chemicals attacks silica.

CAUTION

The strong chemicals called for in this article are dangerous unless they are used carefully. Take the same precautions exercised in a school chemistry laboratory.

If chemicals are spilled on the body, wash the area with copious amounts of water and then see a physician.

If they get into the eyes, irrigate the eyes constantly with lukewarm water for at least half an hour, and call a physician. Have handy a rubber tube that can be fitted to a mixing-type water faucet in case such emergency irrigation is necessary.

These treatments must be done outdoors or under a chemical hood. If the home fireplace has a good draft, it may be substituted for the hood. The various boilings in strong acids must be undertaken in small amounts and with great caution; avoid inhaling the fumes or spilling any of the acids on the hands or clothing. Use rubber or plastic gloves to protect the hands. Manipulate the test tube with a test tube holder, or clamp and see to it that any fumes are carried away from you by the draft. Use an alcohol lamp or a Bunsen burner (gas turned very low and pass the base of the tube through the flame tip, back and forth, to bring on the boiling gradually. Never boil so vigorously that any of the mixture escapes from the tube.

Store the diatom valves in distilled water, adding peroxide, formalin, or alcohol to prevent bacterial or other growth

;ach storage tube should be carefully fully labeled. Let us say a par- lar collection was obtained from mley's Pond, Poddawodammee, Pa., ·il 15, 1966. It is hence fresh water Recent (the present geological iod), abbreviated FR. (A convenient em classifies all your diatoms on es as fresh water, brackish, or marine as fossil or Recent — thus six sets of e initials cover these classifications: FR, BF, BR, MF, and MR.) All rmation may be put on the label, or may number each tube serially, the ıbers referring to a card index record re the details appear.

'hen you're ready to mount the dia- valves, wash out the preservative add distilled water; agitate the tube oring the diatoms into suspension, pipette one drop onto a slide. Ex- ıe under the microscope to observe concentration of the valves. There ıld be many present but not so many ɔ form clusters; they should be well ad to permit study of individuals. To ıin a heavier concentration, if neces- , add another drop or two of the ended diatoms to the slide. If the :entration is too heavy, add more dis- l water to the tube. Now breathe on oroughly cleaned cover glass and im- iately add one drop of this adjusted ension, which should spread into n film. Invert a glass vessel over this r to protect it from the dust while ng. Since the least trace of moisture spoil the slide, it is more profes- ıl to dry the prepared cover glass hot plate.

hen it is absolutely dry, put a drop ountant in the center of a clean slide, the cover glass, diatom side down, the mountant, one edge of the cover hing the slide, and let the cover gently onto the mountant.

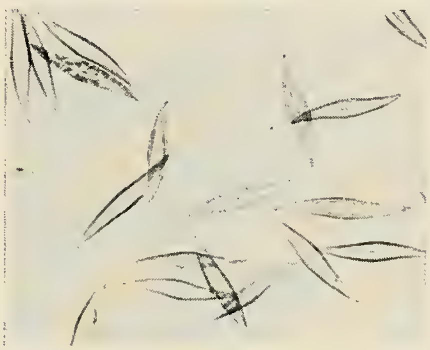
'apped air within the diatoms is a tious problem in mounting them on s, but heat will usually remedy the ɔle. If air appears in a finished and l slide, place it on the hot plate for ile. This will melt the mountant and l the air, whereupon the slide is ved to cool and again solidify.

ıe slide just described is called a ity strew because it is a random ɔle from one area.

Making a Species Strew

species strew, all of the valves are a single species. They may all have obtained from the same locality or various places. This procedure in- ıces the more exacting technique of ting single diatoms and requires the opment of skill and precision.

ɔette a number of valves from your ed material onto a slide in a large of water and examine uncovered r the microscope. As you locate and ify a particular species, such as *Surirella gemma*, remove it to a tube of distilled water marked for that species. This is done for as many different kinds as you encounter, and before long you will have dozens of vials that are separations for each of many forms. From one of these you may then make a species strew, as you would have made a locality strew. No attempt at any arrangement of the valves is made, as the term "strew" indicates.



Species strew has diatoms of one species.

How does one pick up and transfer a single tiny diatom? It can be done under a hand lens or low-power microscope (stereo perferred). While there are instruments for picking up one at a time, a moistened, fine-pointed brush (no. 00) of badger or camel's hair, or a single badger hair from a shaving brush or water-color artist's brush, may be used. Older diatomists prided themselves on the possession of, and *expertise* in the use of, a tiger whisker, grasped by the fingers alone, or mounted on a dowel or needle holder with shellac, sealing wax, or household cement, but one of the larger whiskers (vibrissae) from a household cat will serve (better get one from a laboratory specimen, not from a living animal). A diatom will adhere to the moistened brush or whisker tip and may be moved from place to place. Another method that serves well in transferring specimens in water is to use a micropipette. Glass tubing of the diameter of the ordinary medicine dropper type of pipette is drawn out over a flame to a very fine diameter, cut to the desired length, and equipped with a rubber bulb.

As sources of knowledge of diatom taxonomy, there are atlases with beautiful plates and books on diatoms available in libraries. Also, type slides are obtainable from supply houses. In these, several diatom species are arranged in one or more rows, and the slide is accompanied by a typed list of their names. Type slides are available with 10 species, or 20, 30, 50—even as many as 100. You can also buy such a slide with the name of each diatom appearing in print beneath the specimen. Genus type slides are similar, but present several different species from the same genus.

The simplest of those slides in which the diatoms are accurately positioned are called circle slides. Here is the way to make them:

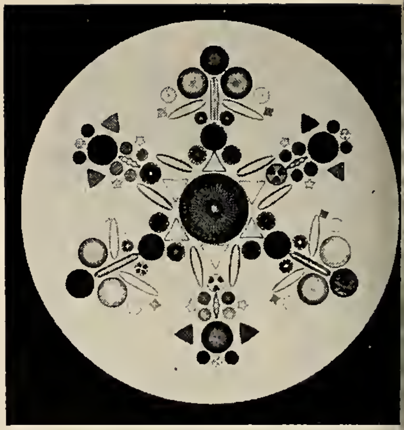
The first step is to locate the exact center of a blank slide. To do this, place the slide on a 3 by 5 index card and rule around its outline in ink. Now connect opposite corners of this rectangle on the card with ruled lines; the point at which these diagonals cross marks the center. When a slide is positioned over this card, the inked lines show through the glass, marking the center.

Now select a round cover glass of any size you prefer. On it rule ink lines that cross at right angles along two diameters, to mark the center of the circle. Position a blank slide over the centering card and the prepared cover glass over the slide, with the centers of each coinciding, then rule around the cover with a fine pen. You now have a slide with a central ruled circle, which will serve as a positioning device when the slide finally is covered. (After the slide is finished, this circle is washed off.)

Now it is time to mark smaller, concentric circles within the guide circle and on the other side of the slide (the side on which the diatoms will later be mounted). To do this you need a small turntable, available from commercial dealers. Position the slide accurately on the center of this table, mounting side up. Dip a fine-tipped brush into gold size, asphaltum varnish, or any of the newer lacquers; rest the heel of the brush hand on the stationary portion of the turntable device; give the wheel a spin; lower the brush to make contact with the slide; and thus turn a ring of any diameter you desire. Build up the ring a bit by repeated applications. Also, you may want to make rings of several different diameters (some quite small) on one slide, to identify the positions of various diatoms more easily when viewing them through the microscope.

The slide's upper surface, on which you have marked the concentric rings, is now coated with any of several media into which the diatoms are to be transferred. Gum tragacanth is one of the older substances employed. Breathe on it to moisten slightly, pick up the diatom with the whisker, place it where desired, whereupon the gum sets and holds it in the chosen position. While the gum is moist, the diatom may be poked with a hair to the exact spot wanted. Bellido's acetic gelatin is easier to use than gum tragacanth, and less messy; make it of equal parts of liquid gelatin and 50 per cent acetic acid. Another formula is clove oil, 2 parts, and acetone-soluble celloidin, 3 parts, spread as thinly as possible.

When all valves have been affixed (use about 50 per slide in your first attempts), dry the slide completely, using a hot



Exhibition slide takes skill and practi

plate, then add balsam and a cover gla

Many workers prefer to make th mounts on the cover instead of the sli using the same methods. When ab lutely dry, invert the cover, diatom si down, upon a drop of mountant in t center of a slide. If you use this meth the concentric circles must be spun the cover glass (the side on which t diatoms will lie) instead of on the sli

Making Exhibition Slides

EXHIBITION slides are the finest a most beautiful examples of t mounter's art. They are made in the sa manner as circle slides, but the diato

Dr. Corrington, who is well known in the field of microscopy, is a retired Professor of Zoology from the University of Miami in Florida.

e accurately positioned to present a ›ometrical pattern—a star, rosette, heel, or other design. Examine texts id catalogues to see illustrations of me of these. Commercial slides are offred with 25, 50, 100, and sometimes ore diatoms. In this case the diatoms e not all different, but certain types e repeated according to the pattern osen, such as round species for axes id elongate ones for radii. Draw lines paper to guide you in placement of e diatoms, and put the slide over the iper as you mount the specimens in me geometric form.

Fossil species should not be neglected the embryo diatomist. Start by obining a lump of diatomaceous earth by ld work or by trading or purchase. eak it up into pea-sized pieces with an pick, but do not pulverize.

Place a layer of these small pieces in saucepan and cover with a layer of otographers' hypo crystals (sodium posulphite). Heat over a flame until hypo crystals are melted and the rth fully saturated with the absorbed, elted hypo. Allow to cool for an hour, en add more hypo and reheat to insure orough impregnation of the earth.

Let the mixture become cold. The hypo ll recrystallize, expand, and break up earth to its finest particles. Fill the n with cold water, producing a muddy iss that will soon separate into a botn sediment and a floating scum. The liment will contain all solid foreign itter and broken diatoms, the scum ly perfect diatoms, buoyed up by air pped within the frustules. Skim off s surface accumulation as long as it itinues to form.

First, wash the skim with water to reve all traces of the hypo, then boil for minutes in a strong solution of washsoda (sodium carbonate). Wash iin in water. Then go through the ene cleaning procedure as described for ›paring Recent diatom frustules, inding the boilings in hydrochloric, ric, and sulphuric acids and the aching in potassium chlorate.

Finally, you can mount the fossil dians in the same way you would Recent ves and frustules.

is list details the photographer, artist, other source of illustrations, by page.

ER—Karl Kenyon
1—Joan Mencher
:pt map,
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5—John G.
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7—Evelyn Shaw
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G. Vandenbergh
9—AMNH Archives
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32-39—Bryan Nelson
40-41—Charles L. Hogue
42-49—Philip C. Hammond
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Brunt; map, AMNH after
Hammond; diagram,
AMNH after H. Stigers
50-53—Ian Michael
Wright
54-57—Lee Boltin
60-61—Philip L. Feinberg
62—Philip O. Gravelle

Suggested Additional Reading

NAMBOODIRI BRAHMANS OF KERALA

LAND AND SOCIETY IN MALABAR. A. C. Mayer. Oxford University Press, London, 1952.

THE COCHIN TRIBES AND CASTES. L. K. A. Krishna Iyer. Vol. II. Chap. 9-11. Luzac & Co., London, 1912.

CASTES AND TRIBES OF SOUTHERN INDIA. E. Thurston. Vol. V. Government Press, Madras, 1909.

NAMBOODIRI BRAHMINS: AN ANALYSIS OF A TRADITIONAL ELITE IN KERALA, INDIA. J. Mencher. *Journal of Asian and African Studies,* June, 1966.

RHESUS MONKEY BANDS

NATURALISTIC BEHAVIOR OF NONHUMAN PRIMATES. C. R. Carpenter. Pennsylvania State University Press, University Park, 1965.

PRIMATE BEHAVIOR. Edited by I. DeVore. Holt, Rinehart and Winston, N.Y., 1965.

PRIMATE SOCIAL BEHAVIOR. Edited by C. H. Southwick. Van Nostrand Co., Princeton, 1963.

THE AFRICAN BAOBAB—OBJECT OF AWE

KENYA TREES AND SHRUBS. I. R. Dale and P. J. Greenway. Hatchards, London, and Buchanan's Kenya Estates, Ltd., Nairobi, 1961.

FLORA OF WEST TROPICAL AFRICA. J. Hutchinson and J. M. Dalziel. The Crown Agents for the Colonies, London, 1927-37.

THE MAN-O'-WAR BIRD

WIDEAWAKE ISLAND. B. Stonehouse. Hutchinson, London, 1960.

HANDBOOK OF NORTH AMERICAN BIRDS. R. S. Palmer. Yale University Press, New Haven, 1962.

LIFE HISTORIES OF NORTH AMERICAN PETRELS AND PELICANS AND THEIR ALLIES. A. C. Bent. Smithsonian Institution, Bulletin 121. Government Printing Office, Wash., 1922.

HIDEAWAY FOR MOTHS

A PYRALID INHABITING THE FUR OF THE LIVING SLOTH. H. G. Dyar. *Proceedings of the Entomological Society of Washington,* Vol. 9, pages 142-44, 1907.

GENERAL ENTOMOLOGY. S. W. Frost. McGraw-Hill Book Co., N.Y., 1942.

ANCIENT HEBRON, THE CITY OF DAVID

ARCHAEOLOGY IN THE HOLY LAND. K. Kenyon. Ernest Benn, Ltd., London, 1960.

THE ARCHAEOLOGY OF PALESTINE. W. F. Albright. Penguin Books, Baltimore, 1963.

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ARTICLES

DEPARTMENTS

COVER: This handsome young warrior, named Khuung, is one of the Montagnards, who live in the mountains of Vietnam. He is a member of the Ma tribe, which is part of the same Proto-Indochinese group as the Mnong Gar, whose way of life is described in an article starting on page 8. The hairdo and necklace he is wearing are frequently the adornments of men. The decorations he has stuck into his chignon are a small knife, a wooden comb covered with tin, various feathers, red pompons, and beaded pendants. The ear disk is of ivory. On his shoulder is a *wiah*, an efficient bush knife; the bamboo handle is tin-sheathed.

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RESOURCES AND LEGISLATION

Washington newslett

By Paul Mason Tilden

Since the last installment of this column the nation has acquired a splendid new seashore—Cape Lookout, whose 20,000-odd acres of dunelands and marsh will encompass some 58 miles of North Carolina's Outer Banks. It is a long, thin (from less than ½ mile wide to about 1¾ miles at its broadest point) strip of land lying, on the average, some two miles off the mainland. Commencing at Ocracoke Inlet on the north, with only a mile of water separating it from the southerly terminus of existing Cape Hatteras National Seashore, the new reservation will run in a southwesterly direction down Portsmouth Island and Core Banks to a point southeast of the city of Beaufort, where it will swing west to include the Shackleford Banks.

The legislation bringing Cape Lookout into the national park system was never controversial during its steady progress through the necessary hearings and final adjustments, and as a consequence, perhaps, was but slightly followed by the lay public. Thus, authorization of the new seashore came as something of a surprise to many people. Underlying this idyllic state of affairs was the generosity of the state of North Carolina, which undertook to donate to the American public some 18,000 of the 20,000 needed acres. It is worth noting here that North Carolina has had a past record of such generosity in the establishment of parklands and seashores, notably in the cases of Great Smoky Mountains National Park and Cape Hatteras National Seashore.

The newly authorized seashore will be similar in general characteristics—flora, fauna, geologic history, and scenery—to Cape Hatteras National Seashore; indeed, during its consideration by Congress there were suggestions that the area might merely be added to Hatteras, or, at the least, administered by the personnel of that seashore. In any case, Cape Lookout joins the list of East Coast sun, sea, and sand reserves that have been added to the park system in recent years —Cape Cod in Massachusetts, Fire Island in New York, and Assateague in Maryland and Virginia. Cape Hatteras, in North Carolina, is an older seashore, first authorized in 1937 although not formally established until 1953.

Redwood Park Proposals

An unfortunate cleavage appears to be developing over the size and location of a possible Redwood National Park in the marvelous redwood groves that grow along California's northern

The early months of 1966 hav the introduction of several score authorizing a Redwood Park, and can be fitted into two general cate Bills of the first sort would create of about 45,000 acres maximum s the addition of some 25,000 acres t fornia's Jedediah Smith and Del Coast Redwoods State Parks in Del County, plus a detached strip of redwoods along Redwood Creek n town of Orick in Humboldt Coun ther south. Such bills are in accor the Administration's proposal for wood National Park.

Bills of a second type have been duced by a number of conservati scious congressmen, who would es a much larger park of some 90,00 in the Redwood Creek and Prairie valleys of Humboldt County. Thi would resemble the preserve outli the National Park Service as "Pl in a brochure released more than ago and discussed in a previous " ington Newsletter." Typical of th is legislation introduced recently ator Lee Metcalf, for himself and half of fourteen other senators, form of an amendment to the Ad tration's bill in the Senate. Senato calf's amendment would bodily sub the larger park for the Administr smaller one. As foreseen in the pr discussion of a redwood park on pages, the cost of a meaningful ar logically complete reserve—an enti wood watershed—would be very The sum suggested in the Metcalf a hundred million dollars for dir quisition money, plus fifty millio which to match private or state do of money or property toward the As of this writing (early April) n lic hearings had been scheduled appropriate committees of Congr a park of either size.

Incident in the Snake Ran

An irritating incident in easte vada's Humboldt National was the cause of recent conserva protest to the United States Fores ice and to interested congressmen

During recent years it has beco parent that the bristlecone pine *aristata*, sometimes called the foxt hickory, pine), rather than the sequoia of California's Sierra N (*Sequoia wellingtonia* or *S. gig* depending on one's source of refer

es as the world's oldest living tree, as is now known. The bristlecone, gh unfamiliar to most Americans, actually rare. but rather is a tree erely limited habitat. growing in d stands at high altitudes in the ains of Colorado. northern New o, Utah, northern Arizona. Nevada, astern California. The tree is often ically most rewarding, growing, as specimens do, at timberline or just . where long lifetimes of exposure harshest winds twist and distort ort. thick trunks into gnarled and ted forms.

: bristlecone is also of the greatest ific interest. and has been the ob- f much study in recent years. Re- a has shown an apparent westerly in average "oldest age" of speci- ; that is, there are many specimens eat age—4.000 years or older—in rnia, Nevada, and Utah, but so far presently known. none in the more ly range of the tree. This is a pecu- that is under investigation; but, in vent, the growth rings of the ancient econes have been furnishing scien- with sensitive and accurate clues t climates in the intermontane west, ave shed light on the advances and sions of fairly recent (geologically ing) local glaciers. Cores of long- bristlecones compared with cores of : ancient trees have extended the ing record in one area back nearly years.

specially great interest are the scat- l stands of bristlecone in the eler Peak Scenic Area of the Hum- National Forest in Nevada. which des a line of north-south-trending mountain summits of the Snake ge topped by Wheeler Peak at just 13.000 feet.

low the steep north face of Wheeler itself, at an altitude ranging from) to about 11.000 feet, there is a l of bristlecone pine growing upon morainal material of a former glacier headed in a cirque below the rock and today is represented only by a l patch of ice. In this stand, at an ude of 10,750 feet, grew a bristle- that by 1964 had attained a circum- nce of 252 inches a little above nd level, but a height of only 17 feet e top of its dead crown.

ith permission of the Forest Service, tree was cut down during the sum- of 1964 by a young scientist from an ern university in connection with a y of distribution pattern of age limit e bristlecone. In the summer of 1965 study was published in a scientific nal. There was no indication in the y report that the tree had actually . destroyed, and it was early 1966 re conservationists learned the full ils of the incident.

s it turned out, the bristlecone proved to be about 4,900 years old—oldest living tree of any species identified to date and some 300 years older than a known 4.600-year-old specimen in the White Mountains of eastern California. One conservationist sourly remarked that the world's most ancient living tree had been simultaneously discovered and destroyed. The Forest Service attempted to defend itself by saying in part that the tree was in poor health anyway; conservationists retorted that most ancient bristlecones consist of much dead and very little living wood. and that this particular tree had probably been "ailing" since the birth of Christ. But the real burden of conservationist complaint was: Why was the well-known and non-destructive technique of coring for tree age not used in the case of the Wheeler Peak bristlecone? Competent opinion seemed to indicate that coring would have served the purpose of the study equally well. The preservation faction of the conservation movement was particularly disturbed about the destruction of the bristlecone, since the Wheeler Peak area has for many years been viewed for inclusion in a proposed Great Basin National Park.

Protest could hardly bring the oldest tree back to life, but it might prevent further errors in judgment in the management of the Wheeler bristlecones: I have learned unofficially that steps have been taken to insure the future safety of the ancient trees.

The Oil-Shale Question

An issue of great interest to the American conservation movement, which loomed large. but ill-defined. on the horizon for a number of years, has moved considerably closer to the mainstream of conservation events during recent months. The issue revolves around the eventual management of an immense treasure of potential energy lying largely in the public domain of several western states in the form of so-called oil shale. More closely defined. this is a fine-textured sedimentary rock that can be made to yield oil in appreciable amounts by destructive distillation of included plant and animal matter. Such organic-rich shales are widely scattered about the world. and have been utilized on a small scale for many years in areas where petroleum has been expensive or hard to obtain; low-grade. organic-rich shale deposits were worked to some extent in the eastern part of the United States before the great petroleum discoveries began just prior to the Civil War.

Current interest, however, focuses on some 16,000 square miles of basin terrain in Colorado, Wyoming, and Utah. which are underlain by the Green River Formation, deposited during the Eocene Epoch as fine sediments at the bottoms of freshwater lakes (Natural History, April, 1965, p. 10). Within four such basins—

the Piceance in Colorado, Uinta in Utah, and Green River and Washakie in Wyoming—the Green River rocks possess a potential oil equivalent yield, in known high-grade deposits of 25 to 65 gallons per ton of rock, of some 600 billion barrels. Intermediate-grade deposits yielding 10 to 25 gallons per ton in the four fields would, it is estimated, add another 1,430 billion barrels to this figure, while known deposits yielding only 5 to 10 gallons per ton—too low a grade of shale for present technology to deal with—are thought to have a 2,000-billion barrel potential; the whole constitutes a reserve of something like the equivalent of 4 trillion barrels of oil, or many hundreds of years' supply at the nation's present rate of use. Even this figure, some geologists think, might be doubled by possible extension or upward revisions of Green River shale resources.

Figures of this magnitude are impossible to comprehend, but viewed in terms of either profit or protection from competition, they offer a good reason for the current interest in western oil shale.

About 85 per cent of the organic-rich shale in the four basins lies in public lands administered by the Department of the Interior, the balance being privately owned. The figure for federal lands includes a relatively small percentage of lands that private individuals hold in unpatented oil-shale placer-mining claims, filed before the Mineral Leasing Act of 1920 was passed; if the claims were validated, the land would become privately owned. The 1920 Act removed the oil-shale deposits from location under placer-mining law, and made them subject to lease; but in 1930 they were completely withdrawn from leasing by proclamation of President Hoover, and they have continued in a withdrawn status to the present.

For a number of years the Interior Department has been under pressure for a decision in the matter of opening up the oil-shale lands to lease for private development. During the spring of 1964, Secretary of the Interior Stewart L. Udall appointed seven prominent Americans to survey the problems of oil-shale development on federal lands. "If the national interest is to be served . . . the major public policy questions need to be identified and evaluated at the onset," he said, naming the following persons to be members of an Oil Shale Advisory Board: Chairman, Joseph L. Fisher, president of a research organization, Resources for the Future; Benjamin V. Cohen, attorney of Washington, D.C.; John Kenneth Galbraith, noted economist; General James M. Gavin, U.S.A. (ret.), chairman of the board of Arthur D. Little, Inc.; Milo Perkins, business consultant; Orlo B. Childs, president of the Colorado School of Mines; and H. Byron Mock, Salt Lake City attorney. General Gavin resigned from the Board fairly early and did not sign its report to the Secretary.

In the question of oil-shale land leasing, the Secretary's "major public policy questions" seem numerous, and include many problems that would fall directly within the purview of the conservation world. Among these one might list the impact of strip mining, with all of its dismal potentials for water pollution, erosion by wind and water, and damage to the natural scene and its wildlife and vegetation; the disposal of huge amounts of waste rock and spent shale from processing plants; and the potential air and water pollution of the distillation plants themselves.

In early 1965 the Board submitted an interim report, complete with the private views of members, to Secretary Udall. Beyond general agreement on the fact that "orderly development of a competitive oil shale industry would provide future sources of oil of much benefit to the country," no consensus was developed on the question of whether the Secretary should, or should not, authorize oil-shale leasing in the near future. Three members favored immediate leasing and three were opposed, so that the Secretary was left in pretty much the same policy quandary he had found himself in earlier.

Perhaps the views of economist John Kenneth Galbraith most nearly expressed the views of the conservation world in the matter, so far as those views have crystallized. "The major oil companies are naturally concerned with protecting their position in the event of the development of an oil shale industry by buying or controlling oil shale acreage," he said. "There is good reason . . . to seek the development of effective and economical processes for recovering oil from shale. Alternative fuel supplies are, however, wholly sufficient to permit orderly and equitable development of shale oil resources . . . there need be no irrational or helter skelter alienation of this public resource. All who believe in conservation must resist such course."

Storm on the Hudson

SEVERAL years ago a New York public utility requested the Federal Power Commission's authorization of a large pumped-storage hydroelectric plant on the Hudson River near Cornwall, some miles above New York City. The company plan called for a 12-billion-gallon reservoir atop the Hudson Highlands adjacent to the river, to be filled with water drawn from the Hudson during hours of low electrical energy demand, for release and power generation in hours of peak demand. The power plant, envisioned as the largest of its kind in the world, would be housed in a deep, 800-foot-long excavation in the solid rock face of Storm King Mountain and connected with the reservoir by penstocks (sluices), c

s for which would also be blasted m the face of the mountain. The en- y developed would be transmitted th to the power grids of New York y over high wires centered in a 250- t-wide cleared right of way.

'he plan was immediately opposed by roup of Hudson River residents and servationists who felt that the power nt and its transmission network would esthetically damaging to a reach of Hudson that still possessed a consid- ble measure of its original charm and ndeur, and that still offered the mil- s of residents of New York and its llite cities a scenic and recreational ıge. Led by an organization titled the nic Hudson Preservation Conference, empest was stirred on the Hudson. t tempest may, whether the hydro- nt is eventually built or not, have a tle impact on future management of nation's river resources.

'uring mid-1964, a trial examiner for Federal Power Commission recom- ıded that the utility be granted a li- se for its Storm King project. (Such a ommendation becomes final if, within lays, no exceptions are filed and the Commission feels no need for review s examiner's decision.) However, the nic Hudson Preservation Conference file an exception, requesting a ruling ne full Commission. In early 1965 the ng was published, and it appeared to titute a defeat for the stubborn Con-

Mr. Tilden, a writer and an editor in the nation's capital, often contributes columns that pertain to government legislation and our natural resources.

ference. In its "green light" to the utility to commence construction, the Commission said that "on balance the issuance of a license appropriately conditioned to avoid unnecessary harm to the landscape or to other public or private interests . . . is desirable and justified in the overall public interest. . . ."

Conservationists had argued in vain that there were alternatives to the Storm King project; that interties with power sources in adjacent regions—Canada, for example, which is looking toward New England and New York as outlets for its tremendous projected Hamilton Falls power plant in northern Ontario—would serve peaking power needs; that power companies to the south that are using, or plan to use, mine-mouth, coal-fired generating plants in poverty-stricken Appalachia could furnish the needed peaking power; that a highly efficient gas-turbine generating plant using surplus natural gas (many are in use throughout the country today) would serve as well or better. This latter suggestion had been advanced by the former chief engineer of New York City's Bureau of Gas and Electricity, but had been rejected in the FPC's 1965 hearing as "untimely."

But the Conference was not yet ready to throw in the towel. It appealed the FPC's decision to the United States Court of Appeals for New York. In late December of 1965 the utility's plans for the project were halted when Chief Judge J. Edward Lumbard and Judges Paul R. Hayes and Sterry R. Waterman set aside the FPC's licensing order.

The Court said that the Federal Power Commission had failed to compile a record sufficient to support its decision; that the record on which it bases its determinations must be complete; and that its refusal to receive testimony in regard to the gas-turbine proposal exhibited "a disregard of the statute and judicial mandates instructing the Commission to probe all feasible alternatives."

Especially significant to the conservation world was this statement in the Court's opinion: "The Commission's renewed proceedings must include as a basic concern the preservation of natural beauty and of national historic shrines, keeping in mind that, in our affluent society, the cost of a project is only one of several factors to be considered."

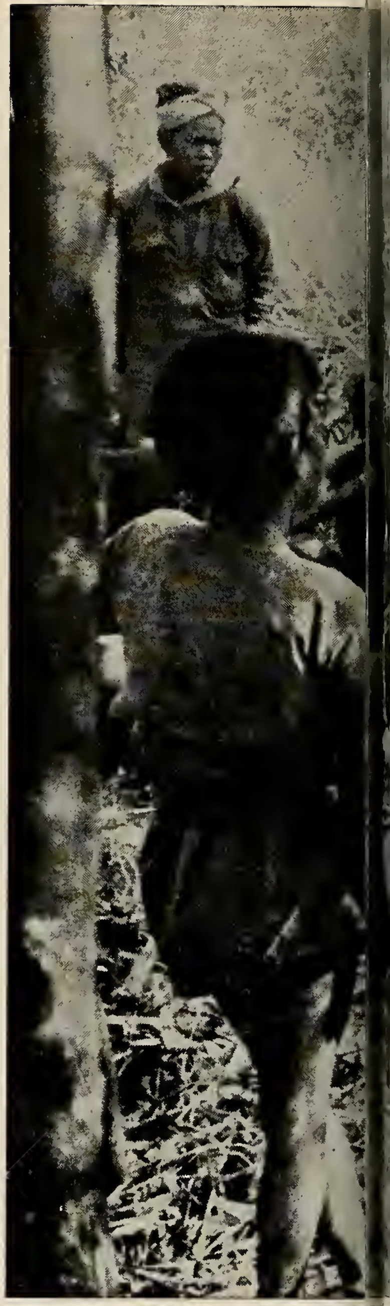
Not long after the Court's opinion was issued, the FPC set a new date for hearings—October 17, 1966. But just before these lines were written the utility announced that it would take its case to the Supreme Court rather than to the FPC for new hearings. Conservationists will await the Supreme Court's decision with the deepest interest.

The Primitive Life of Vietnam's Mountain People

Occasionally in the news dispatches from Vietnam there has been mention of native tribesmen known as Montagnards, or mountain men. The following account of these little-known people is given by a French anthropologist who lived among them for about two years and was adopted as a member by the tribe he describes here.

In addition to giving a general picture of the Montagnards, the author tells of one of their most distinctive traditions: the incest taboo.

by GEORGES CONDOMINAS



The Montagnards of Vietnam are a so-called primitive people: that is, they follow an ancient way of life in the mountainous jungle regions that rise above the coastal plains. Technically speaking, the inhabitants of the coastal plains are the Vietnamese proper.

Ethnic groups similar to the Montagnards are found throughout Southeast Asia. All the plains people of these countries have given derogatory names—"savage"; an equivalent of the American "hillbilly"; "slaves"; and others—to their indigenous mountain tribesmen.

The adoption of local names for the Montagnards has been a source of confusion, so A. G. Haudricourt and I coined the word "Proto-Indochinese" to designate this whole group of tribes that had found refuge in the mountains of the Indochinese peninsula, from the Bay of Bengal to the Gulf of Tonkin, and along the Chinese frontier to Singapore.

But, except to ethnologists, these tribesmen are still known by the name given to them by the French—Montagnards.

The Mnong Gar, who are the subject of this article, are one of the most primitive tribes of the Proto-Indochinese group. The other mountain tribes call them the Phii Brêe, which means "men of the forest." They occupy both banks of the mid-Krong Knô, "The Male River" (in Rhadé language followed by the geographers), southern branch of the upper Srépok River, a tributary of the Mekong. Their habitat is a country of hills and mountainous foothills, covered by jungle, bamboo groves, and in places, dense forests. This terrain, which harbors big game—elephants, tigers, gaur (wild cattle), deer of all kinds—is situated about 200 miles north of Saigon, just south of the magnificent Daak Laak (Darlac) Lake Basin, where a relatively good road leads to the city of Ban Mé Thuot.

How They Dress

The Mnong Gar dress essentially the same as the other Proto-Indochinese of Vietnam. For this entire group, the most typical part of the men's costume is the *suu troan* which is a type of loincloth. It made of a long, narrow strip of clo that is passed between the thighs b fore being wrapped around the wa and knotted at the loins. The m richly decorated end of the *suu tr any* falls from the waist in fro much like a narrow apron. The *s troany* leaves the legs and buttoc completely bare, and is often the on thing worn by the men during t day, although they may sometim add a short, sleeveless tunic to the co tume. When cold comes in the ev ning, they wrap themselves in la blankets and gossip in the courtya with their neighbors. The same bla

Members of the Mnong Gar tribe of Montagnards take part in a ceremony in a bamboo grove in interior Vietnam.

t is used during the day to carry ung children on the back, and at ght as a cover during sleep.

The women wrap a skirt made of rectangle of indigo-dyed cloth ound their waists. The two ends erlap in front and are held in place a narrow belt. They may go about ked to the waist or wear a tunic, ually long-sleeved. Imported, ady-made clothing is becoming pular today, and the women often y black calico skirts and white cot- n blouses. But it is the men who are ost eager for European clothes— ckets, shirts, overcoats, and capes. ey are not interested in shorts, and ll less in trousers.

Both men and women wear their hair in a chignon, but today most of the young men, and especially those of enlistment age, cut their hair short, "European style."

Both sexes adorn themselves with many bracelets and necklaces. The women decorate their hair with strings of tiny beads arranged like a diadem, and stick large hairpins of various shapes in their chignons. Men more commonly wear wooden combs covered with tin, and on feast days they add two red pompons.

The Mnong Gar mutilate their teeth, for purely "esthetic" reasons. They break the upper incisors and file them to the gumline; the lower teeth are filed to a point. All the teeth are painted with black lacquer.

The picture of the man of the forest would be incomplete without a basket, a bush knife, and a bamboo pipe. (The women also smoke pipes; in addition, they chew on a sort of "pipe cleaner" made of a long sliver of bamboo, one end of which has been frayed into a little brush. When the pipe cleaner is drawn through the bowl and pipe stem, the brush end collects all of the tobacco juice.) The basket (*sah*) is carried on the back and held in place by two

braided rattan straps, which pass over the shoulders. The bush knife—the inseparable companion of all Montagnards—has a short, wide blade and a bamboo handle more than a yard long. The knife blade is fixed in the bulbous root of the bamboo, which has been prepared by bending the root at right angles to the bamboo shaft. Thus the bush knife can be balanced on the shoulder, with the blade turned upward (*cover photograph*); the handle is usually gripped while walking.

Grain is harvested by Montagnard tribesman, above. The men of these tribes mutilate teeth for "beauty."

The Dwellings

What is most striking about the Mnong Gar dwellings is their length (at the village of Sar Luk, where I lived, two of the houses measured more than forty yards) and their massive thatched roofs. In fact, the roof is almost all that one sees. The thatch slopes from either side of the ridgepole, which is three or four yards high, to about two feet from the ground. Thus, the low, woven-bamboo wall of the house is almost completely hidden by the thatch. The roofing is rounded at either end of the house. The doors are hardly more than low, narrowing openings in the front wall, and above them are arches of rattan that serve to raise the edge of the roof so the people can pass through the doors. Just under the eaves, near the doors, are long, narrow chicken coops.

The area that surrounds each house separates it from the one it faces, and this area is generally kept rather clean and neat. It is weeded from time to time, and some people even sweep the area daily. But, inevitably, it becomes a quagmire during the rainy season.

Very close to certain of the dwellings—those of the *kuang*, the "men of power"—tower tall, straight, thorny trunks of false kapok trees, *Bombax malabaricum* (De Clercq). The tops have been carved and crowned with a twig of decorated bamboo. These are the posts that have been used for buffalo sacrifice. Some of the older posts throw new roots and again become tall, beautiful trees, a living testimony to the prestige of those who planted them. Sometimes, in front of such a house, is an immense, decorated bamboo, which can shoot up to more than sixty feet, thus completing the ritual decor.

The houses' interiors are dark ar almost empty except at the bac where a third of the width is occupic by an enormous dais made of planl or woven bamboo, which is about foot off the ground and runs the er tire rear length of the house. Again the wall behind the dais is a row large jars. Over the large jars har one or two tiers of little, neckle jars. The number varies with tl wealth of the master of the hous Each end of the large room, the *wa* (which we shall refer to as the recep tion room), is bounded by an in mense rice granary, set on four c six strong stilts. These pillars are a extension of the two lines of columr that support the roof parallel to tl ridgepole.

Weirs like this in Krong Knô River at Vietnam village of Sar Luk are built by mountain tribesmen to lower the water level, making it easier to net fish in basketwork scoops. Women join fishing party, photographed by author in 1958.

ıch granary occupies only the lle third of the width of the long- e. The back third is occupied by lais, part of which serves as a bed :he master and mistress of the e. This sleeping area of the dais lineated by a board or a pile of ets or boxes, which separates area from the reception room. front third of the longhouse is, in rast, kept clear, except for a dish , or, at worst, a neat pile of fire- 1. This front third thus forms a dor through which passage from :nd of the longhouse to the other ıimpeded. Except for each ex- ity of this large dwelling, the ıries are grouped in pairs with back partitions touching. It is is point that the *nal*, or private opens in the front wall.

ıe women do the cooking under ow floor of the granary on a h composed of three cylinders : of packed earth from a termite When all of the women in the ıouse are cooking, smoke in- ; every corner including the re- ɔn room.

ch granary belongs to one inde- ɛnt family. If the family con- ɔnly of a couple and their young :en, the family limits itself to a ıry with four pillar supports cov- a single hearth. But if the fam- cludes several adults—a newly ıed daughter or the widowed er or sister of one of the couple granary has six pillars and cov- /o hearths, one of which is used e mistress of the house and the by her protégés.

ıus each family's domicile is de- ned by its granary. To refer to someone's residence, one says *hih nâm* (house granary), whereas *root* refers to the whole longhouse, which contains several *hih nâm*.

Agricultural System

Like most of the other Proto-Indochinese, the Mnong Gar are seminomadic farmers who practice *miir*, a method of shifting cultivation that consists of clearing a section of forest, burning what has been cut, and sowing the paddy (rice grains) over the field fertilized by the ashes. The field is abandoned after one harvest (sometimes, but rarely, two). In this way the crops are moved almost every year, and the same area is replanted only after a fallow period of about ten or twenty years. When arable land is too far away to be convenient, the village site may be moved. But should an epidemic result in the death of several residents, the village is always relocated. Village sites that have been temporarily abandoned can be identified by the presence of fruit trees or edible plants, such as a type of eggplant, and by the rows of false kapok trees—memorials to buffalo sacrifice.

These shifting cultivators can reckon the passage of time only by a spatial reference point—that part of the forest that has been felled and burned—in short, by the "eaten" forests. In this way, they designate each year by the name of the eaten forest. When the Mnong Gar wish to calculate the exact age of a child, for example, they need only recall the name of the forest eaten at the time of his birth, break one twig for each of the forests eaten since that event, and count the total number of broken twigs. The title of the book on which this article is based, *We Have Eaten the Forest of the Rock Spirit Gôo*—as translated from French—simply stands for the year 1949 at Sar Luk. It was in this village that I lived from September, 1948, to February, 1950, after several months traveling in the region to learn the language.

Even without cultivation, the forest offers important sources of food: wild vegetables and plants, such as leaves of *pae sei* (*Gnetum gnemon*), bamboo shoots, and various tubers, and game, which the Mnong Gar usually trap. (But fishing is by far a more important source of protein than trapping.)

The Mnong Gar raise some smaller animals for food: pigs, chickens, dogs, and sometimes a few ducks. Buffalo are very difficult to raise and are usually bought from other tribes and used as the sacrificial animal of choice.

Commercial Activity

The tribe engages in other productive activities. Their basketry is of excellent craftsmanship. This is man's work. Weaving is done by women, and it, too, is extremely beautiful.

Commerce is based on a complex system of barter. Each article is evaluated and paid for by a whole series of barterable items: jars, pigs, skirts, and buffalo. The most valuable items, such as jars and gongs, are not made by the Mnong Gar but, as is the case with other Proto-Indochinese and with Proto-Malays, are ob-

Typical longhouse, left, of the Mnong Gar tribe in Vietnam has immense thatched roof that nearly obscures the walls of woven bamboo. Mnong Gar village above is Sar Lang, situated on a high plain about 200 miles north of Saigon.

Horns of sacrificed buffalo are piled near the outskirts of Mnong Gar village of Sar Lang after Great Earth Festival.

Mnong Gar family, which had stored its harvest in a temporary granary, is now moving the filled baskets indoors.

tained by a long bartering circuit from the plains people. To this system must be added a type of European money, the Indochinese piaster, which came into use a few decades ago. The piaster has been replaced by the *dong*, the official currency of the Vietnamese state. Commercial and all other Mnong Gar transactions are always carried out in the presence of at least one go-between (*ndraany*), but more usually two.

Social Customs

As will become evident in the course of this article, the jar occupies a special place in Mnong Gar life, as it does for the other Proto-Indochinese. The jars are glazed pottery of Vietnamese or Chinese origin, usually reddish brown. Occasionally the word "alcohol" will be used to describe their contents, but in fact, this term is something of a poetic exaggeration. *Rnööm* is nothing more than a rice beer that cannot really be compared to either our distilled spirits or our wines. The beer mash (*coot*), which is made of rice flour and rice husks, is allowed to ferment for several days (or at most about a month) in a sealed jar (*yang*). If there is to be a sacrifice, a small amount of *coot* is taken for the anointment, and then the jar is prepared in the usual manner. It is stuffed with leaves or sword grass to keep the fermented material on the bottom of the receptacle, and the jar is filled to the brim with water. The quantity of water added varies from about one to ten quarts, depending on the size of the jar. The *rnööm* is now ready, but before it can be drunk it must be consecrated. A drinking straw (*gut*) is stuck into the jar as several verses are recited; care is taken to insure that a few drops of water fall on the ground.

The beverage is drunk by drawing on one end of the *gut*, while the other end touches the bottom of the jar. The drink becomes alcoholic as the water flows through the fermented mass. One drinker may not be replaced at the jar by another until the first has drunk two draughts of *rnööm*. (If a singing contest is in progress, then the number of draughts to be drunk, always even in this case, must be equal to the number drunk by the preceding contestant.) In addition, the next drinker does not take his turn until the assistant sitting at the opposite side of the jar has added twice the contents of a fire-etched bamboo tube, buffalo horn, or plastic glass that has been filled with water from a receptacle by his side. Thus, as each drinker takes his turn, the *rnööm* becomes progressively weaker, and after a few hours it is quite innocuous.

After having finished this article, the reader may come to the conclusion that the Mnong Gar are consummate drunkards. But the majority of the days described here are special occasions. Besides, I am under the impression that the men of the forest are not the only people in the world to douse a marriage or a wake. Not only is their only strong drink less alcoholic than any of our mass-produced commercial spirits, but, in addition, their opportunities to drink are considerably less frequent than ours. The Mnong Gar only uncork a jar when they must pay honor to the spirits or to a visiting foreigner. More is necessary than direct satisfaction with water. To indulge in a drinking party without having a religious motive—merely for the sake of social drinking or solitary tippling—is inconceivable to them.

efore their country was included e political system of the French nial regime, the social space of Mnong Gar did not extend be- l the territorial limits of the vil- Today, they are all included in erarchy of administrative organ- on maintained externally, but the ge system remains as a substruc- Each village includes three or "sacred men in the forest and village," who serve both as arbi- for the collective rituals, such as agrarian rites and village recon- ction, and for the problems in- ing land—in particular, the selec- and apportioning of forest lots to aten.

man becomes a *kuang*, that is, a of power, when he has amassed igh possessions to immolate a alo. Each additional buffalo ifice adds to his prestige, espe- y when an exchange of sacrifices *n bôh*) is involved. An exchange acrifices creates a strong alliance veen the two celebrants.

he shaman, too, occupies a spe- position in Mnong Gar society. shaman (*njau*) is the intermedi- between the patient and the *caak*, malicious sorcerers, and the *ig*, the spirits inhabiting nature. he Mnong Gar family organiza- is principally based on the *mpôol*, ch we translate as "clan": that is, roup of individuals who claim a nmon maternal ancestor. The n name and the family possessions transmitted, not by the father to children, but by the mother to the dren. For example, the members the clan Rjee belong to the clan ause their mother, not their ier, belongs to it. Members of the ie *mpôol* may neither marry nor e sexual relations with each er. They are, in fact, considered sisters and brothers if they are of same generation; as fathers, thers, and children or uncles, nts, nephews, and nieces if they ong to two succeeding genera- is; and finally as grandparents and ndchildren if they belong to two ierations separated by a third. No tter how far back the first common nale ancestor may be found in the iealogy, two individuals that for wouldn't even be considered as isins call each other "mother" and iildren" or "brother" and "sister." is this situation that forms the sis of the tragedy to follow.

The "Incest" of Tieng and Aang ....Who Had A Common Ancestor 15 Generations Ago

This account is taken essentially unedited from my diary. It forms part of Chapter III of the book, Nous Avons Mangé la Forêt de la Pierre-Génie Gôo, *published in 1957 by Mercure de France, Paris.*

VIETNAM, NOVEMBER 26, 1948

At a quarter to six in the morning they came to take me to Kröng-Jôong's house for the great annual sacrifice, "The Blood Anointment of the Paddy" (*Mhaam Baa*). He is one of the sacred men in the forest and the village at Sar Luk, and he observes and executes the rites most meticulously. Yesterday had been devoted to a preliminary rite, "The Taking of the Straw" (*Sok Rhei*) and, like all the agrarian rites, it had ended with a drinking party. This drinking party will continue, without letup, throughout the next few days devoted to celebrations of the agricultural cycle. The Blood Anointment of the Paddy comes as a brilliant climax to the end of the year.

When I arrived, Kröng was preparing the rice-flour paste that he would use to paint geometric designs on the pillars and beams of the granary, and then on all of his household possessions. He was painting the jars when Kroong-the-Big-Navel burst in shouting: "Aang-the-Widow has been lying with her brother Tieng!" [The Mnong phrase was much more crude.] Baap Can, who had been sitting by the fire smoking, stared at Kroong in bewilderment. He didn't seem to understand. Kroong repeated his sinister news. Then Baap Can

Like every Mnong Gar man on eve of a harvest, Kröng-Jôong "announces his harvest to people of the underworld" (his ancestors) with token offerings.

turned to me: "Serious *beng* [taboo]," he told me. "Sticking a knife in a pot, *beng;* copulation between sister and brother, *beng*." And he added, "The lightning strikes," and with his hand he made the gesture of cleaving his skull in two. Kroong told us how he and Kraang-the-Bladder had surprised the couple last evening behind Chaar-Rieng's hut. They had recognized Tieng at once by the gleam of his tin comb, and had shouted at him. The man had bolted, dropping a hairpin from his chignon. They had picked it up to use as incriminating evidence. Aang, who was drunk, had not moved. She had just lain there, stretched out on the ground.

"Who was it?"

"I'm drunk. I don't know."

"It was Tieng, your own brother."

"How should I know?"

Tieng had remained in hiding in the bush. Meanwhile, some of the other drinkers joined Kroong and Kraang to question Aang, or to comment on the scandal. No more had been seen of Tieng last night. He waited until all the curious had retired before sneaking back to Chaar-Rieng's hut. Chaar-Rieng was his *kôony* (mother's younger brother), with whom he lived.

— — — —

Aang-the-Widow could hardly be called beautiful. She had a bad figure, was flat-chested and swarthy. Yet, her expression was witty, and what was rare for a Gar girl, her eyes had an ardent expression. She lived with her brother Tôong-Biing, a calm, stolid fellow who was an excellent basketmaker, but terribly poor. Her eldest brother, Sieng, also widowered, lived at Little Sar Luk, a hamlet of only one hut about two miles from the village.

On the other hand, Tieng was one of the handsomest men in Sar Luk. He was always impeccable. His hair was pulled tightly into a chignon, and it was always decorated with a big comb and a handsome, tin-plated pin. He wore necklaces around his neck, bracelets on his arms. His apron loincloth was tied tightly around his waist. When Tieng's wife died, his uncle Chaar-Rieng went to Phii Srôony to get Tieng and his five-year-old daughter, Jôong, and brought them to Sar Luk to live. Tieng's eldest brother still lived in Phii Srôony, the family's original home.

I had been aware that Aang often hung around Chaar-Rieng's place, especially when his nephew was there. I had only a vague impression that they might be lovers; the Gar are always very discreet. But I had quite forgotten that they were of the same clan. Aang and Tieng were both of the *mpôol* Cil.

A few days earlier, when I was working at my desk, I heard cries from Tôong-Biing's hut. I rushed out and asked someone else who had also been attracted what was happening. "Tôong-Biing is beating his sister," was the reply.

"Why?" I had asked.

No answer.

They told me the reason today. Biing, the wife, had been scolding Aang for flirting with her brother Tieng. Aang not only told her to mind her own business but, when Biing continued to reprimand her, Aang slapped her face. When her husband returned, Biing told him what had happened. Tôong was furious and gave his sister a good beating. So, although people had been aware of the incestuous relation betwen Tieng and Aang, nobody had yet caught them at it.

— — — —

Baap Can had recovered from his astonishment. He was now bursting with indignation.

"The lightning strikes," he said, "when sister sleeps with brother. . . It strikes not the guilty, but the lea[ding] men of the forest and village.

> *The dragon flays . . .*
> *the tiger devours . . .*
> *the elephant impales*

the sacred men in the forest and t[he] village. It is a very serious matt[er]. The offenders must *saa ê'* [eat exc[re]ment] of pig, dog, hen, duck, a[nd] man."

I asked him: "You mean rea[lly] eat?"

"No, only lick with the tip of t[he] tongue. Then the rain will stop. It['s] *beng* for sister and brother to sle[ep] together. When the couple are of d[if]ferent clans, though, it isn't *beng*."

Baap Can was convinced, as we[re] the others, that once the expiato[ry] sacrifices had been performed, the[ir] incestuous relations could not lead [to] a birth. [But Aang gave birth to a s[on] in July, 1949.] Nevertheless, inc[est] brings the threat of unnatural dea[th] to all people of importance: that [is,] not only to the traditional *kuang*, b[ut] to people like Truu, the canton he[ad] living at Sar Luk; his deputy; a[nd] even to me, because I am closely i[n]volved in the life of the village. Inc[est] disturbs the order of nature. The ra[in] will dig deep ravines, cause lan[d]slides. Water will gush from the ear[th].

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The celebration of *Mhaam B*[...] was not interrupted by the disclosu[re] of the scandal, but the incident [of] Tieng and Aang was to provide a su[b]ject for discussion in every home an[d] for Baap Can, an opportunity to di[s]play his learning. He would sing t[he] "verses of justice" (*noo ngöi dôih*[)] blaming the couple for their obs[ti]nacy and emphasizing the horror a[nd] disgust aroused by their misconduc[t].

About ten o'clock, Krae, the hea[d]man of Bboon Rcae, turned up [at] Sar Luk completely drunk, bawli[ng] and gesticulating, his eyes bloodsho[t]. (Bboon Rcae is an administrati[ve] area formed by Sar Luk and near[by] Paang Döng.) He was of the *mpô*[*ol*] Cil and went into a fury when [he] learned what had happened in h[is] clan. He burst into Chaar-Rieng['s] house in a drunken rage, shrieking[:] "We must tie them up! Bring them t[o] trial immediately." Then he ran, sta[g]gering to the canton deputy's plac[e], still shrieking, "Tie them up."

Baap Can arrived and tried t[o] calm him down. He declared that th[...]

ple could not be tied up, that they dn't even be judged on the spot. he improvised these lines:

rink well, eat well,
omorrow we will pass judgment.
runk with beer, drunk our body,
oo would take no account of it . . .
omorrow we'll all question them.
ang has made love with Tieng.

is song explained that people busy with *Mhaam Baa* today; should drink and have a good . Tomorrow would be time igh to settle the matter. There is me for everything. (*Yoo* is a ong word by which they had ed me—fully, Yoo Sar Luk.)

ut Krae would not be dissuaded. o one would listen to him, he ld tie them up himself. He would them to the lake. He was, after a headman and a Cil. I, too, tried et him to listen to reason, but he inued to argue. Finally, someone ed the problem by sitting him n in front of a jar. After drinking ill, he fell asleep.

uring the morning the sky had kened. The storm broke at about in the afternoon. We were to four days of torrential rain ken only by periods of drizzle; r somber days without a ray of shine on a sea of mud and water. r and over a lamentation was rd: "Rain, terrible *beng;* love-king [again, their term was more thy] between sister and brother. n."

VEMBER 27

The *Mhaam Baa* sacrifices went We were at the venerable Tôong-ng's house. He was speaking of terday's downpour, today's eatening weather, and the drizzle. doubt there would be a devasta- deluge. Such were the conse-nces of incest.

Taang, eldest brother of the of-ding Tieng, arrived a short time from Phii Srôony. He has gone h Chaar-Rieng to the residence of ang-Jieng-the-Stoop-Shouldered, hest Cil in the village. The two n seemed weary, depressed by the ormity of Tieng's offense. Never-less, Chaar competed with Baap n in reciting the Cil clan geneal-ies (Baap Can's father was also a). Sieng-the-Widower and Tôong-ng, who were too poor to manage en a proper *Mhaam Baa,* were squatting discreetly in a corner. They were crushed by what had happened.

This evening it was the canton chief Truu's turn to perform his *Mhaam Baa.* I was greatly surprised to find Aang serving the company, bringing tubes of rice beer to the various guests. She moved among us, naked to the waist, and wore no ornaments. Her skin seemed a little darker than usual. Was it shame, or the result of having drunk too much last night? Her gestures were clumsy when she attempted to mix with the others, but she didn't seem dejected in the least. Rather, she appeared to be surprised by all the commotion her affair had caused. Moreover, the discussions went on in front of her, as if she were not there. Everyone was scornful of the *mpôol* Cil; even Truu, whose father was a Cil, spat on the ground to show his disgust.

Somewhat later in the evening Tieng appeared. He had not been seen since the night before last. It was his uncle's turn to make the sacrifice, and he had come to invite us to drink at his place. Handsome Tieng, usually so elegant, was completely undone. He was wearing none of his ornaments; his hair was disheveled and his features drawn. His eyes avoided ours. He hadn't dared to raise his voice for the invitation.

Receiving the "feeding exchange" in a ceremony of "exchange of buffalo sacrifices" is Baap Can, who is one of the accusers in the Mnong Gar incest case.

NOVEMBER 28

The sacred men shared the gifts among themselves. Each household had given chicken legs and measures of *rnööm* as a payment for their participation in the rituals performed during these two days of sacrifices. All of the men of the village were there because the division of lots in the new *miir* would be discussed. Inevitably, the talk came around to the case of incest, and they speculated on how Aang would manage to get a pig for the sacrifice because her brothers had none. Her brothers have decided to go to work on a plantation. The salary will be meager, but enough to complete the sum necessary to pay for the piglet. In addition, Tôong-Biing, an excellent basketmaker, will weave me some carrying baskets and winnowing baskets for the Musée de l'Homme.

Bbaang-Dlaang, the sector chief, came through Sar Luk to pick up Truu and some of the young villagers. He came to see us, and repeated what he had told the old men yesterday: Although the incestuous couple would have to make the expiatory sacrifices, they would not have to

Early in the ceremony at riverside to expiate the incest, Aang's brother Tôong-Biing prays before a small altar.

pay the fine. Normally a case of incest is settled in the following way: If the guilty couple is rich, they must offer for sacrifice a buffalo with horns a cubit in length (about half a yard). And they have to provide five *rnööm* between them. In addition they must each give three large, old jars. This entails a heavy expenditure. But if the guilty couple is poor, they must offer a pig with a five-span measurement (the circumference just behind the forelegs; a span is the distance between outstretched extremities of the thumb and middle finger), one jar of rice beer, and two large jars each, as a fine. The jars given in payment of the fine are shared among the sacred men and the other *kuang*, for it is the men of importance who have the most to fear from the consequences of incest.

Finally, around noon, Kroong-Biing (known as Kroong-the-Short) arrived. He was wearing a magnificent coat of long black pile, cut in the European style. Kroong-the-Short is the "brother" (first cousin, for us) of Baap Can and Truu, and like them, his father was a Cil. He is a renowned judge, a "man of great learning," and he had been asked to participate in the trial.

It was decided that since Truu and the young men accompanying him were absent, the group would proceed only with the settlement of the Tieng affair. Aang's sacrifice would be put off until the district chief and his companions returned. In actuality, the affair had already been settled during the discussions around the jars. It now was only a matter of legal and public recognition of the offense and of carrying out the sentence—the sacrifice.

When we arrived at Chaar-Rieng's place, two medium-sized jars (*yang drôh*) were already tied to a stake. One member of the group explained that the two *rnööm* were Tieng's. He had used the two *yang drôh* because he didn't have a large jar; in fact, one of the jars had actually been given by Aang. The pig had been firmly tied to a pillar by the hind legs. It was squealing and struggling violently. One of the men pulled a long straw from the roof, and with another man's help he took the piglet's measurement—two spans and two fingers.

The offending couple was then ordered to summon the whole village. Aang was embarrassed and hesitated. Tieng scolded her a little to work up his own courage. He too seemed afraid to take that step. Little by little the house filled. The women, most of them carrying babies in blankets on their backs, slipped in and squatted under the granary. Some of the men settled themselves on the dais. Others sat on their heels near the door. Newcomers squeezed in where they could. Finally, Bbaang-Jieng-the-Pregnant arrived. He is the sacred man who keeps the ritual wood used to kindle the fires in the clearing of the forest. He was completely drunk and bawling vociferously. The theme of his tirade was, of course, "lying together, a sister and brother." He was not alone in his drunken state; the drinking straws have seen steady use these last two days. Aang-of-the-Drooping-Eyelid belched in my face that she was drunk (and she was not to sober up for two days). Bbaang-the-Stag reeled after Bbaang-the-Pregnant, waving his arms wildly in an effort to keep his balance. The air had become unbreathable, with so many pipes and the rekindled hearths pr[oducing] smoke that was trapped in t[he] house by the rain. To this was add[ed] the odor of an alcohol-sodden crow[d] which had been drenched in the ra[in] before jamming itself into the hous[e].

Tieng and Aang had returned b[e]fore everyone in the village had a[r]rived at Chaar-Rieng's place. Th[ey] finished filling the jars. Nobody pa[id] the slightest attention to them. T[he] least distracted of the audience li[s]tened to Kroong-the-Short recite t[he] genealogy of the Cil clan in a quic[k]ening tempo. He started with Tin[g] Mang who had four daughter[s]: Loong; Jieng, ancestor of Choo[n] (ex-chief of the canton of Yön Dlei); Dloong, ancestor of Aang-th[e]-Widow; and Bo', the accused man['s] grandmother. The speaker rattl[ed] off the generations of ancestors:

Dloong married Bbaang, bore Grieng, Grieng married Kroong, bore Nguu, bore Ngaa, bore Sraan, bore Laang.
Laang. . . .

When he got to Sieng, Tôong, an[d] Aang (the accused woman and h[er] brothers), he started over again wi[th] Ngaa and recited the genealogy o[f] her father, thus coming to himsel[f], Kroong-Biing.

He recited this double genealogy with an amazing rapidity. By tradition, these recitations have become long poems. The first word of each line is formed by the last word of the preceding line.

Taang from Phii Srôony took his turn in reciting the genealogies. He is Tieng's brother (the same mother and father), and their genealogy is the same as that of Chaar-Rieng, their maternal uncle, in whose house this scene took place.

It is necessary to go back fifteen generations to find the offending couple's common ancestor, Ting-Mang. Actually, I was the only one to have troubled to make this calculation; the sole objective of these genealogical recitations is to provide a formal demonstration of what everyone has been convinced of all along—the couple are brother and sister.

The discussion turned to the procedures to be followed for the sacrifice. It was the drunken Bbaang-the-Stag and Bbaang-the-Pregnant who proved to be the most shrewd. They were the only ones to think of a most important matter, the claiming of the gifts given by the lover to his sister. "Necklaces, bracelets, rings, little bells . . . must all be brought to the watering place," bawled Bbaang-Jieng, guffawing with satisfaction. But Tieng was hardly rich, and the only gift he had given Aang was a small, rectangular box containing a mirror, called *khôop* in Mnong. The *khôop* was added to the hairpin that Tieng had lost when the couple was caught.

Sieng-the-Widower, Aang's eldest brother, tried to give a scoop carved from an internode of giant bamboo to one young man after the other in the group. He wanted them to use it to collect human and animal excrement. They all refused, recoiling. The most outspoken of the young men exclaimed: *"Beng* to pick up dung."

One of them explained: "We are afraid of contagion. We're afraid that lightning will strike us or make us sick."

Another said: "To take the dung of pigs, dogs, man, buffalo, chickens . . . it is sacred [*weer*]. We're afraid of soiling our hands."

So I said to them: "But you collect it to fertilize the vegetable beds." [At the time I was trying to introduce fertilization—without success.]

"For the vegetable beds it is not sacred, but ordinarily it is sacred."

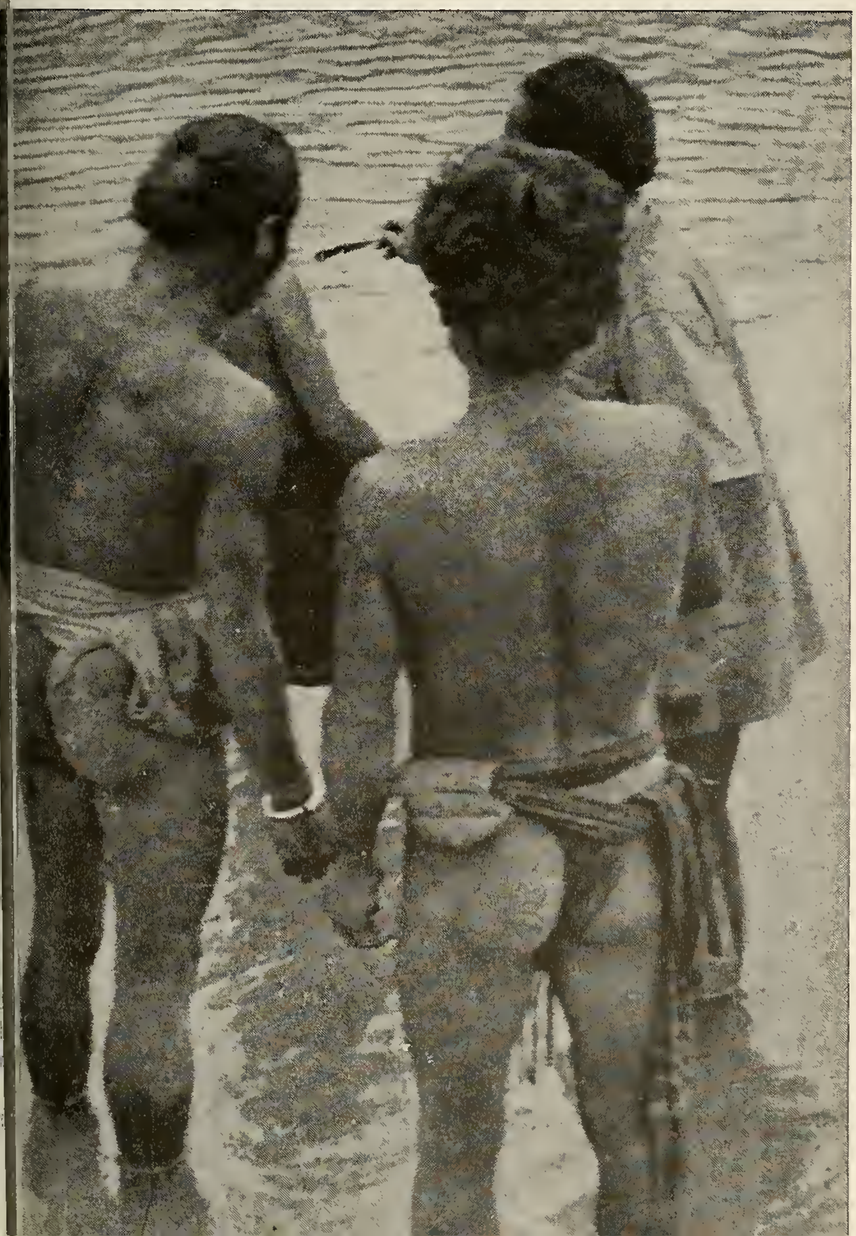
Faced with the refusal of all the young men, Sieng-the-Widower decided to collect small samples of the different excrement himself with a piece of wood. "A little bit of each," Kroong-the-Short told me.

The accused couple did not have a buffalo horn, so instead they filled two bottles with rice beer. Tieng gave his bottle to Tôong-Biing, Aang's second brother, who was carrying a hollowed-out gourd bottom containing beer mash and pieces of charcoal.

When it was time to leave for the ceremony, Aang began to protest: "I was completely drunk. I didn't know what I was doing. . . . I didn't understand what was happening. . . . I didn't know who was covering me."

Her face darkened, and she became more and more obstinate. Tieng was as limp as a rag, but he made a half-hearted show of urging his sister to get on with what had to be done.

It was still drizzling. Early in the afternoon, Tieng carried the piglet down to the watering place, followed by all the villagers, slipping and slithering in the mud. At the junction of the tributary Daak Mei and the river Krong Knô, Tôong-Biing cut a bamboo stalk into three. He took a piece and frayed one end into a tassel, sharpened the other end into a point, and cut a notch in the middle. He prepared another of the bamboo pieces in exactly the same way and stuck both of them into the border of the path that ran above the level of the river. He took the third piece of bamboo, frayed both ends, and set it



Convicted couple is "fed" with excrement of pig and dog. Tieng is at the left, nearly hiding his "sister" Aang.

in the notches of the two upright sticks. He had thus made an H-shaped altar, plumed at the top and crosspoints.

While Tôong-Biing was constructing the altar, the young men immolated the victims. They slit the pig's throat and caught the blood in a large Vietnamese bowl. They poured some of the blood from the bowl over the beer mash and charcoal in the gourd, which Tôong-Biing held. They cut a duck's throat over the same gourd and then allowed the blood to drip into the watering place. Finally, they slit a chicken's throat over the watering place and covered the wound with beer mash. When the mash had become soaked with blood, they put it in the gourd. Thus the gourd contained charcoal plus the elements of each offering: beer mash soaked in the blood of the three victims.

Tôong-Biing set the gourd down at the base of an upright stake and intoned a prayer.

The offending couple came forward. With the thumb and index finger of the right hand they took some of the pig's blood from the large Vietnamese bowl, then the blood of the duck and the chicken by passing these two fingers over the open wounds of each of the victims. Aang and Tieng went into the water together and made an invocation. When it was finished, they dipped their bloodstained fingers into the water, rubbing them together. Meanwhile, Tôong-Biing, still squatting, had gone on praying:

One cannot copulate with his sister;
do not hold it against us, O Spirit.
One cannot exchange sacrifice
with his ancestor;
do not hold it against us, O Spirit.
One cannot marry, if maternal
uncle and niece;
do not hold it against us, O Spirit.
One cannot fight, if father and son,
if termite and termite nest;
do not hold it against us, O Spirit.

He anointed the right *nsôom* (tassel) and then the ground. From time to time, Baap Can or another old man recited some verses aloud with Tôong, without moving from his place.

Sieng put the gifts given to each other by the lovers into the bamboo scoop containing samples of various excrement, and poured rice beer over the whole thing. Then he placed a chicken feather and a duck feather toward the front of the scoop. Now they were ready to proceed with the *siam ê' siir, siam ê' sau* ("giving the excrement of the pig and dog to be eaten"). As the guilty couple waded into the middle of the river, Tieng pretended to jostle Aang to make her go ahead of him. Kröng-Jôong, the sacred man, went into the water, followed by Sieng carrying the bamboo scoop. Kröng-Jôong placed himself in front of the two offenders, at an equal distance from each. He took a feather and dipped it in the revolting mixture and drew the feather first across Tieng's chin, counting "one," and then across Aang's chin, "one," then back to Tieng, "two," and Aang, "two," and so on, eight times. All the while, Kröng-Jôong intoned a long invocation principally intended for the dragon (water) spirit. From the beginning, the backs of the offenders had been turned to us. Each time the feather touched his chin, Tieng was doubled over by violent retching; Aang did not flinch once.

When Kröng had finished his invocation, he threw the feather in the water. Sieng emptied the contents of the scoop in the river, then threw in the scoop. Tieng and Aang washed their chins, legs, and arms. Kröng was on the point of coming out of the water without having purified himself when two or three people in the group shouted to remind him of his oversight. He then went back to the middle of the river and washed his arms and legs.

Tôong-Biing had not stopped praying during the ceremony. Finally, he poured rice beer over the gourd containing the beer mash and charcoal saturated with the victims' blood. He went into the river carrying a bottle of *rnööm* and the gourd, and, keeping the gourd upright on the water, he poured the *rnööm* into it, praying all the while. Then he let it float downstream and begged the charcoal to bring the presents to *Yaang Rmeh* (the dragon spirit). He finished by pouring the entire contents of the bottle into the stream, and returned to the river bank. Everyone went back to the village.

The drizzle, which hadn't let up during the ceremony, became a violent downpour toward the end. But in spite of the rain, the remains of the sacrificed animals would be burned out of doors, because, for this type of sacrifice, it is forbidden to burn the victims indoors, as is normally done with small animals.

The crowd had gathered again a Chaar-Rieng's house. The jars were to be consecrated, and this is the office of "those who have dealt justice." Kroong-the-Short and I were given the first jar. Kröng and Bbaang-the-Pregnant took their places at the second jar. We stuck our drinking straws in the jars, with many invocations referring to the triple sacrifice just performed. I began drinking a the first jar, and Kröng at the second

Then Bbaang-the-Pregnant took the Mnong bowl containing th blood-saturated beer mash and went to his house, accompanied b the offending couple (and me as a observer). The ritual wood for setting fire to the forest was to b anointed. But it was in a large winnowing basket that had been wedge between a rafter and the roof, and they weren't able to pull it out Therefore, they anointed not onl the wood that protruded from th basket, but the basket as well. Th anointments were reinforced by invocations; the only actors in thi scene were the sacred men and th offenders.

Kroong-the-Short had taken m place at the first jar, and he was sti drinking when we returned from th anointment of the ritual firewooc He tackled Tieng. "You can't liv here anymore. You must leave marry elsewhere. . . . I am you *kôony;* come and live with me. Yo can gather the forest vegetables an bring the firewood."

Taang from Phii Srôony backe him up, saying to his brother: "G with Kroong-Biing. Aang will loo for another husband here. . . ." Bu Tieng refused to answer his brothe as he had his uncle.

Kroong-Biing wanted to get h nephew to marry Grieng, a pretty gi who had been pledged to him for debt (no connection with the Grien in the genealogy). When a free ma marries a slave, he does not lose h own freedom, but his children tak their mother's station, and a ma must be a very hard worker if he is t liberate his wife and children. Tien is not. But that didn't seem to b what was on his mind now or wh made him resist so stubbornly.

The fast-talking Kroong-Biing be came more and more persuasiv boasting of his reputation and wealt

itual of the Mnong Gar is "child's outing" seven days after birth. its show son the tools he will use.

e showed Tieng how pleasant life ould be with him at Ndut. Taang ntinued to support Kroong-Biing's oposal, stressing that the offending uple must separate, that a tremenus opportunity was being offered his brother to be able to live with man of such reputation. Taang, at at point, considered the problem ttled, and even went so far as to vise Kroong-Biing to make sure at Tieng would work hard. Tieng, uatting among the men during the ng palavers on his future, had not id a single word. Behind his wall obstinate silence was refusal.

After half an hour of this, Kroong-e-Short decided to change the sub-t. He sang and dictated old songs me. The songs, in which he asted of his amours, soon degen-ated into drinking songs, and even o obscene ditties. There were loud rsts of laughter from everyone; the nosphere was transformed.

Thanks to Kroong-the-Short and e rice beer, the company had relaxed completely. Even the offenders found the new mood infectious. Tieng, who replaced Aang in pouring in the measures of water, had found his voice again. He informed Chaar-Rieng that this very evening he would perform the sacrifice to lift the taboo that was weighing so heavily on himself and his family because of his offense. And, when Aang came to invite me to the sacrifice around eight o'clock, she had the nerve to appear at my house unaccompanied, and being alone with me, she asked for a cigarette. Not a woman in the village had dared to go so far before.

All of the residents of the longhouse had gathered in Chaar-Rieng's place, but hardly any of the other villagers joined us. The events of the day had satiated the curious, and the thirsty had little more to hope for. All that had been done was to prepare a tiny neckless jar (*yang ke' it*) that was put on the ground near the dais. Near the little jar they placed a chicken, whose legs had been tied together, and an empty *yang dâm* (taller than a *yang ke' it*).

Chaar-Rieng had brought his leather pouch, which contained magic quartz stones. He took them out of the pouch and put them in a Vietnamese bowl, which had been placed at the foot of a little jar of rice beer.

Tieng then slit the chicken's throat over the bowl containing the magic stones. Chaar joined his wife, son, and little Jôong (Tieng's daughter) where they were sitting, just under the granary. After allowing the blood to flow copiously into the receptacle, Tieng got up and anointed the foreheads of the other four members of the household with the bloody wound of the victim. Then he took the *yang dâm* in both hands and made eight circles over the heads of the seated group, pleading:

. . . Let the beams of the granary
hold fast,
let the pillars of the granary grow,
let the rice in the big pot cook.
The wild animals follow the night;
the kuang follow the word,
the thunder follows at once.
In future let us seek for buffalo
every day,
let us seek for jars every month,
let us have rice and paddy every day.

He set down the little neckless jar behind the group, but they made him put it in front of them, and everyone touched it in turn. Then Tieng spat in his hand, touched the *yang dâm* and then the chest of Rieng (Chaar-Rieng's wife), repeating the gesture for the other three members of the household (when the person being anointed was a man, he touched the forehead instead of the chest).

Tieng then left the group formed by his maternal uncle's household and went to the one formed by his brother Taang, which included Taang's wife and baby. They were sitting on the dais apart from the other group, because coming from the forest they could not receive "the whirling of the jar above their heads" at the same time as the people from the village. He began the same performance with them. Meanwhile, Chaar put away his blood-anointed, magic stones.

Finally, with the assistance of his brother and uncle, Tieng consecrated the tiny *yang ke' it* next to the dais. The three men coughed slightly and flicked the surface of the water in the *yang ke' it* to sprinkle a few drops of water on the ground. Tieng sucked some *rnööm* into the drinking straw and closed the top end with his index finger. He then went about sprinkling drops of *rnööm* "on the head of the door and on the heads of the hearthstones," repeating his previous prayer. He went back to his two companions, gave the drinking straw to his brother, and took the Vietnamese bowl. With the blood it contained, he anointed the top of the door, the tops of the hearthstones, and the jars. Meanwhile, Taang stuck the drinking straw into the *yang ke' it*. Then he and Chaar repeated the formulas of the vows together.

Now everything was in order. Tieng had cleansed the community, which had been stained by his incest, and purified his uncle's household and that of his brother of the evil he had brought upon them. His offense had been washed away. He had been tense during the performance of the rites. Now his face relaxed. He was a liberated man.

POSTSCRIPT: *Poor Tieng's peace of mind did not last long. The next day he was found hanging by his loincloth from the roof beam of Chaar-Rieng's granary. Perplexed as to how to remake his life, perhaps unable to face separation from Aang, he had committed suicide.*

Lyre-shaped horns and dark markings o its body and face make springboks amon the most beautiful animals on the plain

The Springbok

South Africa's symbol is subject of new conservation researc

By R. C. Bigalke

To Thomas Pringle, a South African nature poet of the nineteenth century, the springbok was a symbol of the wild arid plains of the Karroo. In "Afar in the Desert" he wrote:

> "O'er the brown Karoo where the
> bleating cry
> Of the springbuck's fawn
> sounds plaintively;
> And the timorous quagga's shrill
> whistling neigh
> Is heard by the fountain at twi-
> light grey. . . ."

Gradually the springbok has come to symbolize South Africa itself. The country's international cricket and rugby teams play as the Springboks; in war its soldiers bear the nickname.

For the origin of the name we must go back to the seventeenth century, when the Dutch East India Company founded a provisioning station at the Cape of Good Hope. There its officials met wild animals quite new to them. Some they named after familiar European species. The largest antelope was given the Dutch name for the European elk, "eland." The oryx was quite incongruously called "gemsbok" after the chamois, which is "gems" in Dutch. However, the few European names did not go far among the many different members of the South African fauna, and some of the unfamiliar creatures were simply named after their outstanding attributes. Hence springbok—jumping or springing buck.

It is the only species of the gen *Antidorcas*. The specific name *mars pialis* (from marsupium, a pouch) r fers to the dorsal mirror, or "fan," long white hairs that extends from t center of the back to the tail. When rest they lie in a pouch, as it wer largely hidden by the light brown p lage of the back. In play and certa other kinds of behavior, the hairs the mirror are erected and blosso out into a showy, white, fanlike run patch that is an important commu cation signal. (This is not unlike t "rosette" of the American pronghor described in Natural History, A gust—September, 1960.)

The dorsal mirror is one of two si nificant characteristics that justify t taxonomic separation of the sprin

k from its nearest relatives, ante-
pe of the genus *Gazella*. The gazelles
here are ten African species), the
ringbok, and several other forms
e usually placed in the tribe Antilo-
ni of the subfamily Antilopinae, one
many subfamilies into which the
ge family Bovidae is divided.

The other characteristic peculiar to
e springbok is that it has only two
irs of lower premolar teeth, instead
the three pairs found in most other
embers of the bovid family. The
issing teeth are the first in the bat-
y of grinders, but morphologically
ecause the full mammalian denti-
on has four premolars) they are the
cond premolars. They appear in the
ilk dentition but are not replaced
hen the permanent teeth grow in.
me adults also lack the second pre-
olars in the upper jaw. In a series of
5 skulls, I found these upper teeth
sent in about one half of the males
d one quarter of the females. There
no apparent reason for this differ-
ce between the sexes.

I have emphasized the things that
t the springbok apart. In most char-
ters, however, it closely resembles
e gazelles, and must be considered as
a modified gazelle. The fossil record gives some information on the origin of the springbok. During the middle of the Pleistocene Epoch a number of gazelle species, all of them now extinct, lived in southern Africa. Rock layers dating from either the Upper Middle or Early Upper Pleistocene contain bones that may possibly be those of springbok, but the earliest certainly identifiable fossil remains of the species date from the Upper Pleistocene, and are thought to be between 20,000 and 40,000 years old. By that time all but one of the true gazelles seem to have died out in South Africa. The surviving species, *Gazella bondi*, which may in fact have been a small form of *Antidorcas*, was contemporaneous with the springbok for a time, but when it, too, became extinct, the springbok remained as the only representative of the gazelline group in the southern part of the continent.

The springbok is found in the dry, open country, separated from its (geographically) nearest relatives in the northeast by a "gazelle-free gap." Grant's and Thomson's gazelles come down only as far as northern Tanzania, 1,000 miles north of the northernmost limits of the springbok's range. The gap is a swath of more or less wooded country, the southern savanna zone, which sweeps across the continent and separates the arid and open southwest from the remarkably similar habitats of east-central and northeast Africa. In zoogeographical terms, the springbok is largely confined to the southwest arid zone, while the African gazelles proper occupy the Somali and Sudanese arid zones, a few also extending into the Sahara Desert.

Students of zoogeography have found that the woodland belt of the southern savanna zone interrupts the distribution of a variety of groups. It is now generally agreed that such discontinuous distribution is the result of past climatic changes. During the warm, dry phases of the Pleistocene, the arid plains of southwestern and northeastern Africa appear to have been linked together by a dry corridor, along which an exchange of fauna took place. The hyperthermal phases alternated with hypothermal periods, when cooler, wetter conditions favored the growth of luxuriant vegetation that closed the "drought corridor." The last time this passage was open to dry-country animals may have been 25,000 years ago. After its closure, gazelles could no longer move southward from their northern center of distribution. The springbok must therefore be presumed to have lived in isolation from its relatives for something like 25,000 years.

When colonists first arrived at the Cape, the attractive and abundant springbok drew a great deal of attention with its showy habits. Many nineteenth-century hunters and travelers described the spectacular mass movements, or "treks," of springbok across the semidesert plains of the South African Karroo. My favorite account of the "trekbokke" is the one written by the Scots hunter Roualeyn Gordon Cumming. In December, 1843, he recorded: "I beheld the boundless plains, and even the hill sides which stretched away on every side of me, thickly covered, not with 'herds,' but with 'one vast herd' of springboks; far as the eye could strain the landscape was alive with them, until they softened down into a dim red mass of living creatures." Cumming believed that "some hundreds of thousands of springboks were that morning within the compass of my vision." Yet an old

Dorsal, white hair patches stand erect when animal plays or becomes alarmed.

Boer hunter told the Scot that he had seen, and ridden for a whole day among, even greater concentrations of the animals.

Certainly tens of thousands, probably hundreds of thousands, and perhaps sometimes even the millions of animals mentioned by some of the old writers were involved in the irregular, but not infrequent, eruptions. One may well speculate about the causes for this behavior.

Many theories have been advanced, and a perceptive amateur naturalist, Cronwright-Schreiner, has brought together all the early written material about treks. He also saw the last of the classical treks in the Prieska District of the northern Cape Province in 1896, and was therefore drawing in part on his own observations when in 1925 he wrote in *The Migratory Springbucks of South Africa*, "The treks do not seem to me to be instinctive in the sense in which instinct is seen at work in the annual migrations of certain birds, but rather to be the erratic movements, in search of food and perhaps water, of large numbers of gregarious creatures inhabiting a vast territory which is subject in varying parts to annual droughts . . . but I do not think this explanation necessarily excludes other and obscure phenomena of an instinctive kind from being to some extent operative."

The areas in which the classical treks took place have long since been settled and fenced, and although springbok still occur there, only small herds exist, and their movements are confined. But in the few remaining places where the animals occupy large tracts of wild country, they still aggregate into splendid masses to wander restlessly and unpredictably, apparently in the wake of rainstorms, which bring on a flush of green vegetation. In the vicinity of the Etosha Pan in northern South-West Africa I have seen tremendously impressive congregations of about three thousand.

But they hardly bear mention by comparison with a trek that took place in the Kalahari, on the border of Bechuanaland and South-West Africa, in the winter of 1959. It was estimated by a few local officials that between eighty and ninety thousand animals were massed, a sight I would have dearly liked to have seen.

Because they traversed sparsely populated country, no one was on the spot to study the movement. (Actually, biologists have only recently begun to study the national animal in the field.) Professor F. C. Eloff of Pretoria University collected reports on the 1959 trek, and his views on the causes are quite similar to those of Cronwright-Schreiner quoted above. Eloff notes that treks do not seem to follow a regular pattern, and that rain and grazing conditions are apparently the most important causative factors. He says: "Local belief is that wind and the antelope's sense of smell play an important part in initiating mass movements."

My own studies have led me to similar conclusions. I have worked mainly on large, fenced farms, one of them 30,000 acres in extent and the other with an area of about 100,00(acres. Both are in an arid region witl 15 inches of rain a year. The rainfal is as likely to be below the average a it is to exceed it and occurs as scat tered thunderstorms in summer (Sep tember to March). As widespread general rain is exceptional, it ofte happens that only a small part of farm gets rain and has green vegeta tion, while the rest remains dry. A such times virtually the whole spring bok population concentrates on th green area. Subsequent rain in ar other corner of the farm causes th animals to move there. We have, as result, a small-scale model of a trek. bigger population of springbok occu pying a larger area and behaving i the same way as my farm animal would perform a full-scale trek.

It sounds like only common sense t say that springbok concentrate wher their food is most abundant and mo palatable, and that treks are therefor

simply movements in response to food needs. This is to confuse ultimate with proximate causation. We have yet to discover exactly what stimuli bring herds together into masses and set them off to unknown green pastures. Probably involved is hypersensitivity to a stimulus such as the smell of rain, brought about by living for many months on dry pastures. Social facilitation may also play a part, the behavior of one group nearest the thunderstorm triggering off a following reaction in the next group, and so on. The Bushmen who live in the Kalahari have a simple explanation. They say that the animals follow thunder and lightning!

To put the springbok treks into perspective, I should say that antelope such as hartebeest and gemsbok living in the same areas also congregate in numbers on new pastures. In other parts of Africa, spectacular mass movements of plains animals are well known. The wildebeest migration on the Serengeti Plain is but one other example of a behavior pattern shown by many species of gregarious herbivores in the drier parts of Africa.

The big treks reduce the numbers of springbok considerably. In the old accounts, one reads of herds crossing rivers on bridges made of the bodies of the leading animals, which had been forced in by the pressure of those behind. On at least one occasion a trek ended in the Atlantic, and thousands of carcasses rotted along a thirty-mile length of the west coast of South Africa. Predators followed the herds and probably killed far more lavishly than they were normally able to do. Since treks have presumably been a normal feature of springbok life for thousands of years, they must have been to the advantage of the species. The ultimate benefits must have outweighed the disadvantages stemming from temporary decimation of the population, and trekking must have been biologically worth while if there was selection for this kind of behavior.

One may go on to inquire how an advanced mammal with an efficient system of reproduction, bearing only one young at a time, can afford the periodic, wasteful extravagance of a mass movement that decimates its numbers. Such a species can, after all, only increase infinitely slowly by comparison with, say, a small rodent bearing large litters every month or two.

My studies have shown that the springbok is a fecund animal with a capacity for reproducing at a high rate under favorable environmental conditions. A female is physiologically capable of conceiving a lamb in the first autumn of her life, when she is about seven months old. The gestation period is about five and one-half months, so that she gives birth on her first birthday. I have written "is capable"; whether or not the potential is realized seems to depend at least partly on external conditions. I examined springbok uteruses in three successive winters, and in only one of them were yearlings—20 per cent of the sample of that age—found to be pregnant. In the same year, 94 per cent of the sample of adult ewes had conceived, whereas the proportions in the other two years were only 79 per cent and 71 per cent.

The correlation between a high pregnancy rate in adults and successful conception in some yearlings becomes significant when we look at the weather conditions in the three years concerned. The good breeding year was preceded by a summer of above-average rainfall that was evenly spread, so that the vegetation remained green and nutritious throughout the growing season. Since we know from studies on domestic animals that successful reproduction depends very much on the animals' plane of nutrition, it is reasonable to suppose that good food was largely responsible for the great number of pregnancies observed in springbok.

Weather, acting indirectly through its effect on vegetation, seems to influence the rate of population growth in another way as well. Springbok are seasonal breeders, bearing the majority of their lambs in a brief period of a few spring weeks in September or October. There is also a second peak in the birth curve at the end of summer, in March or April. Usually this second lamb crop is a minor one, but its size seems to be much more variable than that of the principal spring crop. It is conceived approximately when the spring lambs are born. The condition of the veld at that time appears to influence the number of successfully mated ewes. This is inferred because an unusually wet, green spring preceded the one autumn in four when an exceptional number of lambs was born. The mechanism at work is likely to be the same as that in sheep, when they are "flushed," or put on new spring grass, before being mated. Expressed in simple terms, the actively growing grass possesses estrogenic, or female sex hormone, prop-

Herd movements often follow rainstorms, when green vegetation quickly appears.

erties that will stimulate ovulation.

From my preliminary observations, springbok behavior and social organization appear to be similar in many ways to that of several other gregarious antelope that have been studied in Africa during the last few years. The basic social grouping is the female herd, in which adult ewes are accompanied by their most recent lambs. Male lambs tend to leave these mother–young assemblages when they are about six months old, for that is the time when the autumn rut sets in. Actively mating adult rams are antagonistic toward younger members of their own sex, and the young males run mainly in bachelor herds from this time of year onward. In such groups there may also be adult males and, indeed, bachelor herds are sometimes made up only of adult rams.

Solitary males are commonly seen during the dry season, and it is likely that they occupy territories from the onset of the rut in about April until the start of the rains. From then on, moving about after succulent food becomes the most important activity, and a mixing and moving and breakdown of social groupings is apparent. The absence of a rigidly fixed pattern of behavior would, of course, be a valuable adaptation to life in dry areas, where plasticity and opportunism enable an animal to take advantage of temporary sources of nutritious food.

The end of the summer rains marks the onset of the rut. Now one sees small groups of about 15 to 35 females, made up of mothers and their female lambs born half a year earlier in the spring, each group tended by a mature male. It is not yet clear if what are seen as harem herds in the charge of a ram are not, in fact, bands of females temporarily sojourning in one of the many male territories they may visit. Such is certainly the case in the Uganda kob and in the wildebeest, both of which have been studied. Rutting males grunt and bellow loudly on a rising scale, repulse other males that may approach the harem, and chase oestrous ewes in the first stages of courtship. Five and a half months later the young are born.

For the first few days after its birth, a springbok lamb lies hidden, and it usually moves only when its mother visits it to give suck. Once this initial passive stage is over, the young congregate in nursery herds and spend most of their time resting together some distance from where their mothers are feeding. The bond between mother and young is weak by comparison with, for example, a wildebeest, whose calf sticks close to the heels of its mother from the time it is strong enough to do so. Even when the springbok lambs are older and run in the herds with their mothers, they retain the tendency to seek out one another's company. One often sees the lambs clustered together as a subgroup within the resting herd.

When a nursery herd of young lambs is disturbed by a human observer, it "explodes." The little animals rush off in all directions, dorsal mirrors erect and displayed to full advantage by the stiff-legged, hopping gait. The sight of scattering white rumps is certainly confusing to the human observer, and I suspect that a predator, such as a jackal, would find it difficult to concentrate its attention on any one lamb long enough to make a kill. One might make a comparison with the experiments of J. C. Welty, who found that goldfish were confused by very dense concentrations of the water flea *Daphnia*. They kept going after first one flea and then another, with the result that they caught and ate less than when confronted with fewer prey animals.

The erectile mirror of white hairs and the special gait displaying it may be of survival value in the young. Springbok lambs at play also "pronk" (an Afrikaans word meaning to boast, or show off). That is, they move by a succession of stiff-legged jumps with the mirror expanded. Adults respond to some, but not all, alarm stimuli with this gait, and it elicits a quick response, for a single pronking springbok is enough to set off all others in sight. Badly frightened springbok running hard from a man do not usually pronk. They commonly adopt this gait at the sight of a dog. Interestingly enough, the American pronghorn (*Antilocapra*) moves in the same way when a dog comes near. Colleagues in East Africa have told me that both Thomson's gazelle and hartebeest pronk (or *stott*, the usual East African term) when pursued by hunting dogs, but abandon the gait when the predators draw near. Pronking might well be a widespread response of various species of antelope to non-human predators.

In my study, stomach contents were collected only during the winter months of May, June, and July, the time of the hunting season, when material was freely available. We went through the painstaking procedures used by students of herbivore diets—sieving, sorting, and identifying plant fragments. The result of analyzing samples taken from the stomachs of 65 animals painted a surprisingly coherent picture.

Grasses were unimportant food plants. Seldom was there more than a trace of grass in a stomach, and of the 78 plant species that could be identified, only 3 were grasses. Perennial herbs and chamaephytes (small woody shrubs) together made up 68 per cent of the 78 species. Shrubs and trees constituted another 18 per cent. Nearly a quarter of the plant species eaten belonged to the family Compositae, and a few small, woody shrubs of this family made up the bulk of the rumen contents.

In the region where I studied springbok, the perennial grasses cure on the stalk at the end of the growing season. They stay nutritious during the winter and remain palatable to grazers such as cattle. Springbok could therefore live on grasses in the dry season—they would obtain adequate nourishment. That those studied did nothing more than nibble at them shows that non-grasses are preferred. During the rainy season, on the other hand, green grass is eaten readily. A recent study of springbok food habits throughout the year has shown that the principal food plants consist of 45 per cent grass and 55 per cent shrubs.

At present, the springbok is probably the most abundant small, open-country antelope in South Africa. It has survived or has been reintroduced on thousands of cattle and sheep ranches, partly to provide hunting and partly as an additional source of income. Completely wild populations are still found in Bechuanaland and South-West Africa. The total population is probably of the order of at least a quarter of a million, and it may well be greater. Springbok are hunted for sport and, to an increasing extent, for the market. The venison is excellent and the attractive skins are used to make decorative leather goods. Under reasonable conditions, about one quarter of the population can safely be removed each year.

There is little reason to expect that pringbok will decline seriously in umbers or become extinct, particuırly because there are large numbers f them in one national park and two ame reserves. A major gap in our nowledge, from the point of view of ractical conservation is the food inıke and productivity of springbok in omparison with that of sheep, the doıestic animal with which they most ften coexist. The elucidation of this nd other problems will put conservaon on a still firmer footing and will ısure a permanent place for this handome South African national animal ı the open spaces of the country.

Female springbok shows its running gait as it sprints across an African roadway.

Wildebeest, blesbok, and springbok, foreground, graze on a reserve, below.

SINGULAR METAL FROM CINNABAR

Quicksilver has served man since the dawn of history

by PAUL MASON TILDEN

THE heavy, brilliant white metal that appears in the periodic table of the elements as number 80, mercury, commonly called quicksilver, was described in 1746 by Englishman John Hill—author, and translator of Theophrastus' treatise *On Stones* —as "a Mineral of a perfectly singular kind."

In writing this, Hill was no doubt thinking of the long time span during which men had used the silvery element and its compounds in the arts and medicine, and had referred to it in their philosophical speculations about the true nature of matter.

There are many references in antiquity to the use of mercury and cinnabar in the arts and medicine. Native cinnabar was the principal bright-red mineral pigment used in the painting and ornamentation of buildings. "But the painters use this for the sumptuous adornings of walls," wrote the Greek Pedanius Dioscorides in the first century A.D. On the subject of the medicinal use of cinnabar he said "But Cinnabaris has the same virtue that Haematitis [iron oxide] had, being good for eye-medicines . . . for it is more binding and blood-staunching . . . it heals burnings, and the breaking out of pustules." He noted, however, that liquid mercury "has a pernicious faculty being drank. . . ." The Roman historian G. Plinius Secundus wrote about 77 A.D. that "this cinnabaris, too, is extremely useful as an ingredient in antidotes and various medicaments. . . ." Among the "medicaments" of great antiquity was calomel (mercuric chloride), used as a laxative or purgative, according to the dosage. There is good evidence that the ancients were also familiar with the other chloride of mercury—the bichloride—which is a potent poison, nowadays called corrosive sublimate in non-technical usage.

As a cosmetic the mineral must have been used sparingly or only on occasion, for overindulgence must surely have defeated its own purpose through irritation and eruption of the skin. It was learned early that this element and many of its compounds are subtly, and in some cases violently, poisonous.

Perhaps Hill was thinking, too, of mercury as a strange metal that existed as a liquid; one which, he said, "penetrates the Substance of all metals, and dissolves, and makes them brittle." Mercury does, indeed, alloy itself to varying extents with many of the other metallic elements, notably gold and silver. And we still often read that quicksilver is the only metal that is liquid at "room temperatures" or "ordinary temperatures," although this is not quite true since neither of these terms has exact scientific meaning. Two other metallic elements—cesium and gallium—might indeed exist in their liquid forms in the well-heated rooms of many American homes, having melting points in the low eighties, Fahrenheit.

Mercury must have been known at an early date, for during the course of an archeological dig at a site in the Middle East, a grave dating from the fifteenth or sixteenth century B.C. yielded a vessel containing the metal. In addition, the written records of the ancients are replete with references to quicksilver. There is evidence that the Phoenicians, far-ranging businessmen and exploiters of the early Mediterranean world, were trading in Spanish mercury as early as 700 B.C. Chinese records assert that the mausoleum of the emperor Ch'in Shih Huang-ti, who died in 210 B.C., contained a relief map of China in which the ocean was represented by a pool of mercury, and the Yangtze and Yellow rivers by flowing streams of the metal. Aristotle and his pupil Theophrastus, whose lives spanned

Lump of cinnabar is seen on ring at right. To the left, cinnabar in test tube is being heated over burner; the mercury vapor, released by heating, condenses in droplets on walls of the tube. Below, right, metal is shown in large drops. Great care must be taken in extraction process as vapor is extremely toxic.

Fifteenth-century smelting operation used double clay pot with cinnabar in upper part (F). When heated, metallic mercury dripped through layer of moss into lower pot.

parts of the fourth and third centuries B.C., wrote about mercury, and Dioscorides left a fairly detailed account of the way in which mercury could be recovered from cinnabar, its most important ore. It is worth noting that the smelting apparatus described by Dioscorides for reducing cinnabar differed from that used today only in respect to sophistication; not at all in principle. The recovery of the metal from its sulphide, cinnabar, still turns about roasting or baking the ore and precipitating liquid mercury from the resulting vapor.

Today there are two general methods employed in the distillation of metallic mercury from cinnabar. In the first, the ore is heated in a closed retort to a temperature high enough (about 1,200° F.) so that the sulphur component of the cinnabar is oxidized to the gas sulphur dioxide. The mercury component is also vaporized; but while the lighter sulphur dioxide escapes through the exhaust stack at the upper end of the retort, the heavier mercury vapor is discharged into a cooling tube, where it condenses to its liquid form and is then drawn off.

In the second type of distillation operation, the cinnabar is exposed directly to the flame of the furnace in a slightly inclined, rotating drum. Both sulphur and mercury vapors are drawn off at the upper end of the furnace and forced through a series of U-shaped cooling pipes containing water at their lower ends; the mercury vapor condenses in the water while the sulphur dioxide continues through to be discharged to the air.

The roasting of cinnabar has always been attended by certain hazards, and mercurialism, or mercury poisoning, is one of the two longest-known industrial diseases, the other being saturnism, or lead poisoning. Thus, G. Plinius Secundus wrote that "persons employed in the manufactories in preparing minium [a word Pliny used to describe both cinnabar and lead oxide] protect the face with masks of loose bladder-skin, in order to avoid inhaling the dust, which is highly pernicious. . . ." On the basis of modern evidence, loose bladder skins, or, indeed, any other device to prevent inhalation of Pliny's "dust," would have served only to slow the process of poisoning, since the element may possibly enter the body by way of the skin.

Through the centuries there have been many other references to the malignant qualities of metallic mercury absorbed by the human body, most frequently in connection with the reduction of cinnabar by roasting. For example, Vanoccio Biringguccio, Italian mathematician and metallurgist, noted in 1540 that mercury "has the property of contracting the nerves of those workers who extract it from the mine. . . ." The nerve contractions mentioned by this writer were certainly "the jerks" of American mercury miners of a later day—tremors and convulsive movements stemming from several years of cumulative poisoning, usually preceded by other symptoms such as loosening teeth, internal hemorrhaging, salivation (an excessive flow of saliva), increasing irritability and changing personality, and pasty skin color.

Mercury is most actively poisonous in the form of its vapor; but it ought to be remembered, especially by persons working constantly with the fluid metal (as some laboratory workers), that the element vaporizes to some extent even at rather low temperatures—as low as 8.5° F.

The role of mercury and its chemical compounds in modern life is a varied and far-reaching one.

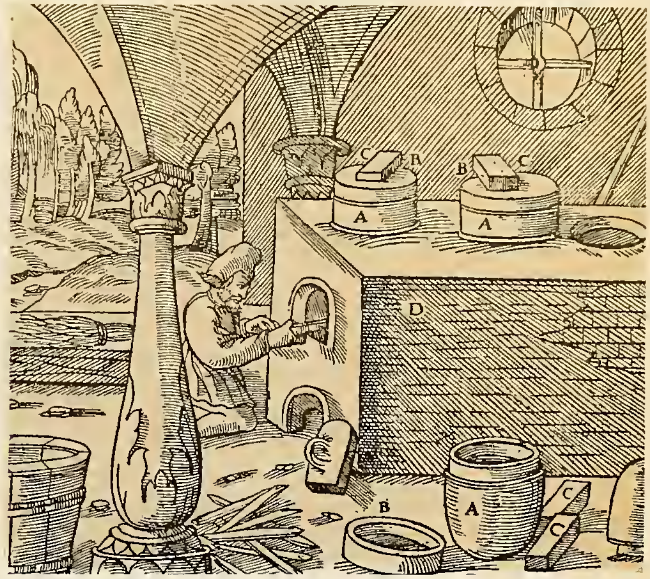
Hollow vaulted chamber (A) contained furnaces similar to (E). Mercury was separated from cinnabar as vapor that condensed on the trees, and ran onto concave floor, right.

Ever since Torricelli, pupil of Galileo, invented the barometer in 1643, weathermen have used the metal in their attempts to forecast changes in the weather. The mercury thermometer is still found in the "little black bag" of every physician. Concerning the medical profession's use of the element, C. N. Schuette, a former consulting metallurgist with the Bureau of Mines, has written in a humorous vein that "thirty years ago the American public was unaware of the fact that it had a systolic blood pressure, while today [1935] some 2,000 flasks of quicksilver are being exercised daily by some 150,000 physicians in determining how high it is." Dentists, of course, use considerable quantities of mercury-silver amalgam in the cavities of their patients' teeth. Calomel, the chloride of mercury, has been used as a purgative for some 2,000 years, and bichloride of mercury is a potent poison and a powerfully corrosive chemical that has long been used as a disinfectant.

But by far the largest portion of the world's production of mercury is utilized in ways that are not so well known to the public. Pesticides and fungicides, for example, consume their share of the element, and special-duty batteries drink a modest portion. The cold white lights so familiar in the meat display cases of our supermarkets are actually mercury-vapor lamps—low-pressure, long quartz tubes containing mercury vapor that glows, under excitation by an electrical current, with a rather ghastly bluish-white light. Along with the visible-light output of the tubes is a rich flow of ultraviolet radiation, to which the quartz tubes are transparent. The ultraviolet retards spoilage of the butcher's wares through its lethal effect on unwanted tiny plant and animal life. The rock and mineral collector uses the same kind of lamp, with an appropriate filter to block most of the visible radiation, in exciting his mineral specimens into fluorescence; essentially, the specimens are reradiating the invisible ultraviolet at optically visible wavelengths.

The electrical and electronics industries account for the lion's share of this metal today. The element is a fairly good conductor of electricity, and finds myriad applications in specialized switches, controls, and other electronic gear for both earthbound and space-vehicle apparatuses. Although mercury is not, strictly speaking, one of the really rare elements, being present in the earth's crust to the extent of perhaps two atoms in every thousand of other elements, its occurrences are localized, and demands of the electrical and space-age industries have recently taxed the available supply sharply. As a result, during the late spring of 1965, the price of the metal reached an all-time high of nearly $8 a pound—more than $600 per steel flask of 76 pounds, the unit in which mercury is marketed. As recently as 1950 the same flask sold for about $80, a little more than a dollar a pound.

Although more than twenty mercury-bearing minerals have been catalogued, all but a small por-



Simple type of furnace had pots (A) filled with crushed cinnabar and ashes. As the heat released mercury from the cinnabar, the metal ran into ashes, then was recovered.

tion of the world's total production of the metal has always been won from cinnabar, the vermilion-hued sulphide of mercury. As attractive cabinet specimens, few minerals can surpass a brilliant piece of cinnabar; from some localities come specimens in which the clean red of the mercury ore is splashed over a snow-white background of quartz or calcite. There is a dimorph of mercuric sulphide, commonly called metacinnabar (also metacinnabarite, or b-mercuric sulphide), of undistinguished gray-black coloration, occasionally found associated with the more common, or a-mercuric, sulphide. Metacinnabar is probably the most abundant of the rarer mercury minerals, which are for the most part of interest only to the mineralogist and mineral collector. Among these minerals are tiemannite and coloradoite, the selenide and telluride of mercury, respectively; two oxychlorides of mercury, terlinguaite (from the type locality of Terlingua, Texas) and eglestonite; natural calomel, or mercurous chloride; an oxide, montroydite; and a sulphate, schuettite (after the expert mercury-mining engineer Schuette, mentioned above).

The economically important ore cinnabar seems to be associated invariably with those portions of the earth's crust that have been subjected to volcanic action or to the influence of hot, mineralized water. Many nations have contributed to the world's supply of mercury—Spain, Italy, Yugoslavia, the Soviet Union, Mexico, the United States, Canada, China, to name a few—but from both historical and economic viewpoints, a single mercury mine in Spain's province of Ciudad Real, the Almaden mine, must take precedence over all others.

The Almaden mine, feeding on cinnabar-saturated quartzite lodes, has been a continuous pro-

ducer of the metal for some twenty-six centuries. Its total production of mercury will obviously never be known, but it remains today as one of the world's most productive quicksilver mines. At some time after the first operation of the property by the Phoenicians in the seventh century B.C., the Almaden fell under the expanding control of the Roman Empire; thus in book 33 of his *Natural History,* Pliny wrote that cinnabar came "from hardly any other quarter but Spain; that of most note coming from Sisapo," which was the district containing the Almaden group of mines. "It is not allowable to reduce and refine the ore upon the spot," he continued, "it being brought to Rome in a crude state and under seal, to the amount of 10,000 pounds per annum." Pliny also mentioned that the agents who shipped the ore to Rome were in the habit of mixing the cinnabar with red lead, which constituted "a source of great plunder to the Company."

In America, cinnabar is found in a number of our western states. California and Nevada have been the two largest domestic producers, with California well in the lead. It was in the foothills of California's Coast Range, a few miles south of San Jose, that in 1845 the mineral was recognized for the first time on lands that are now within the United States. The date of a mineral's discovery has not always coincided with the date of its recognition; and thus it was that the cinnabar outcroppings of Los Capitancillos Ridge, where the Coast Range commences to bulge up at the southerly end of the Santa Clara Valley, were discovered some years before the true nature of the mineral was identified. This recognition was to lead to development of a mercury-mining district, which, while relatively small in area, has furnished the nation with almost 40 per cent of the metal so far produced—more than a million 76-pound flasks—along with a fascinating page in the history of American mining.

California was still under the colors of Mexico when the bright-hued cinnabar of Mine Hill, at the southern termination of Los Capitancillos Ridge, caught the eye of a Mexican settler, Luis Chaboya, in 1824. Perhaps the ore showed tiny smears of glistening native mercury, as it sometimes does elsewhere. In any case, Chaboya was convinced that he had struck a rich deposit of silver, and with a companion set up a small mill to extract the precious metal by crushing the ore and treating it with mercury brought in from San Luis Obispo. The operation, of course, was a failure, and the "Chaboya silver mine" closed. Another effort to extract silver from the red ore was made some ten years later, and was equally unsuccessful; but at least the fancied silver mine had lent some additional weight to an observation made several centuries earlier by Georg Agricola (the German Georg Bauer, known as "the father of mineralogy") that "mining is a profitable occupation to very few men, and a source of loss to many more."

In 1845, a specimen of the ore was shown to Andreas Castillero, a Mexican army officer on his way from Monterey to Sutter's Fort in the Sierra Nevada, who had stopped briefly at Santa Clara Mission. Castillero may have recognized the true nature of the mineral, or he may have shown it to some knowledgeable person on his trip to Sutter's Fort; in any case, he requested and received possession of Chaboya's silver mine from the Mexican government and began operations, with several Indians as miners and some cannon barrels as crude retorts for roasting the ore. Castillero developed the mine rapidly in the following years, and by 1850 Chaboya's silver mine was yielding more than a million dollar's worth of mercury a year, and had hopefully become known as the "New Almaden Mine" after its great Spanish namesake.

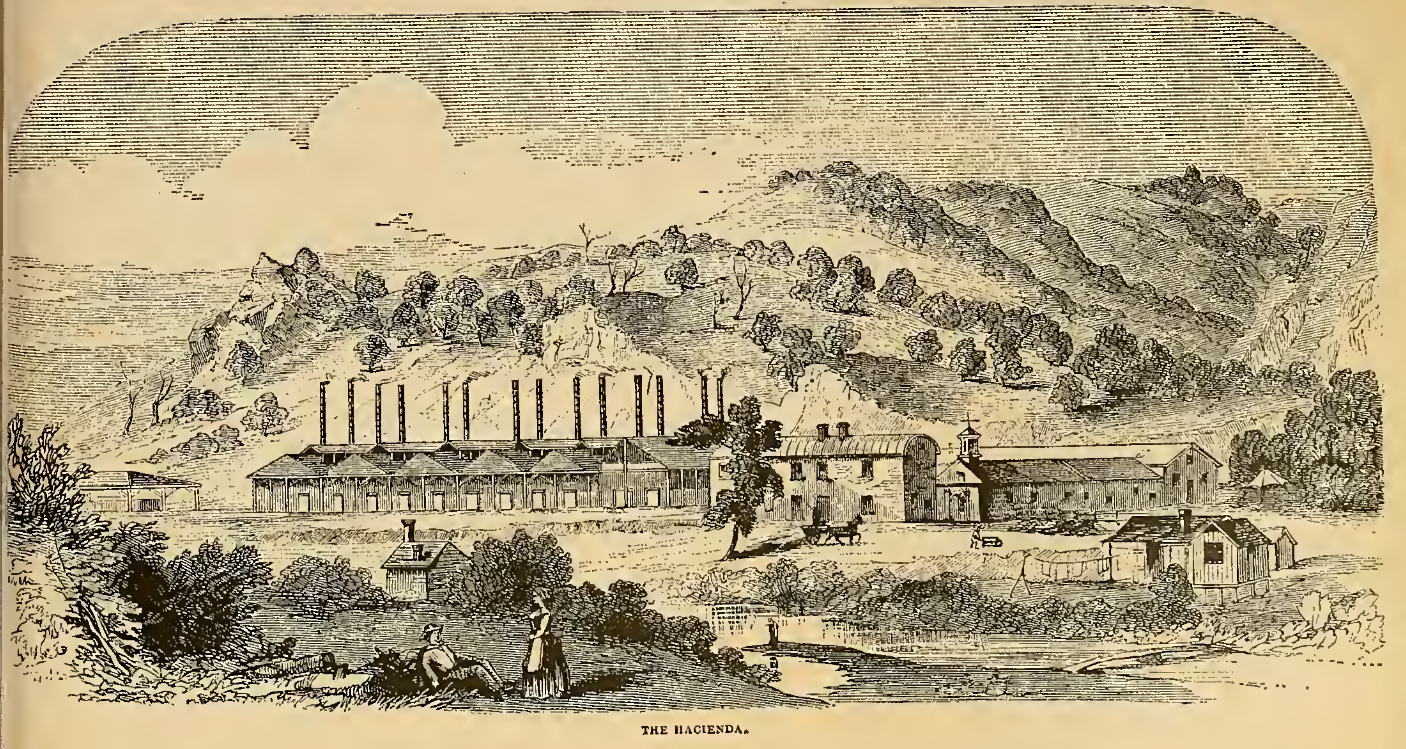
For many years after Castillero first brought the mine into production there was an eager nearby market for his mercury, for at about the same time James Marshall, sawmill supervisor for Captain John Sutter, was picking raw gold from the raceway of the Captain's sawmill in the Mother Lode country of the Sierra Nevada. Liquid mercury was used in the gold camps of the area for "cleaning up" pans and sluice boxes to recover gold too fine to recover by hand. The amalgam formed was usually—and with terrible waste—boiled in a retort to leave a "button" of gold; the mercury was wasted into the air. The seemingly endless flood of placer and hard-rock gold that followed consumed immense quantities of mercury. Thus, the mercury of the New Almaden played a largely unpublicized but critical part in recovering the great treasure that was to affect the economy of the world and establish a basis for the paper money of an expanding nation.

But Andreas Castillero was not destined to remain master of the great New Almaden for long. In 1850, California became a state of the Union, and since title to the mine had been granted to Castillero by a foreign government, there ensued a tangled legal battle over ownership, which lasted for many years—a battle fought through state and federal courts, and all the way to the Supreme Court of the United States, which finally awarded ownership to the American claimants. However, at one point in the legal struggle—during the summer of 1863—public opinion in California became so inflamed over the dispute and the manner in which the government had handled it that the state, with its all-important river of gold, was nearly lost to the Confederate States.

By the end of the nineteenth century, the high-grade cinnabar of the New Almaden had largely been mined out, and production continued on a smaller scale with leaner ore, as it still continues during times of large demand and high prices for mercury. The New Almaden group of mines is no longer the nation's greatest producer; but it will never relinquish its prominent position in the colorful history and romance of the American metal-mining industry.

Yaqui Indians are shown ascending a ladder in the New Almaden Mine. A man carried 200 pounds of ore in leather back pack from the upper level of mine to main tunnel.

Engraving of the Hacienda, smelting area of New Almaden Mine, is from a drawing made in 1854. Building at right was the office; part of it was still standing in 1949.



THE HACIENDA.

Nesting Observation

"Change-over" behavior of Norwegian crane is ceremonious

Common Crane is considered one of the shyest of all birds to observe at nest.

By James Hancock

The Common Crane (*Grus grus*) nests in the northern parts of Europe and Asia, some as far north as the Arctic Circle in northern Scandinavia and Russia. The only other cranes that breed at these latitudes are the Asiatic White Crane (*G. leucogeranus*) of eastern Asia, now a very rare bird, and the Lesser Sandhill Crane (*G. c. canadensis*) of the North American Arctic, a few of which also breed in the extreme eastern tip of Siberia.

Common Cranes usually build their nests in marshy areas well away from human habitation, and the nest itself is made of grasses and other plant materials piled up to form a platform up to two feet high. Here the eggs, usually two, are laid. The incubation period lasts for about 28 to 30 days. Both parents share the duties at the nest, which the young leave about two days after they have hatched.

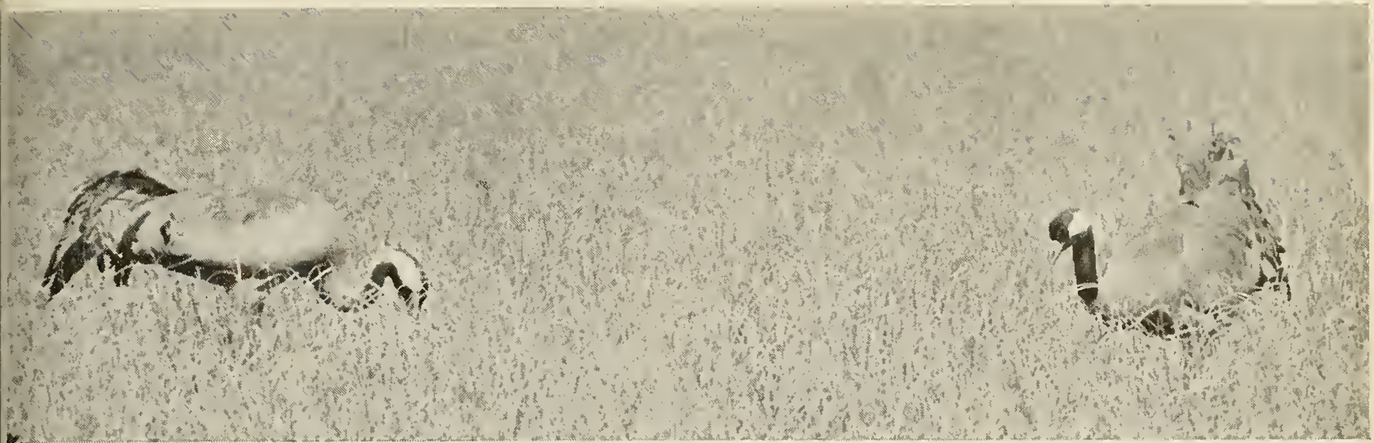
The pictures on these pages were taken at the end of May by Eric Hosking, the well-known British bird photographer, in the Fokstumyra area of the Dovrefjell in Norway. Snow was still lying in quantity on the hills behind the marshland. We erected a blind on the fringe of the marsh among the silver birch whose leaves were still in tight bud, but enough cover was provided to break the general outline of the blind. Observation began two days later, and the birds appeared to accept the blind readily; they incubated and changed over nest duties quite normally. The Common Crane is considered to be one of the most difficult of all birds to observe and photograph at the nest, and as a result we believed that the blind should be in place for at least two days before we occupied it.

The behavior pattern of the "change-over" of birds at the nest, which occurs at intervals of about four hours or longer, usually starts with the relieving bird alighting some distance away and walking toward the nest slowly and carefully. Preening is often carried out during the approach, and a sharp lookout is kept for signs of possible predators. In this series of pictures, one of the birds, with its "tail" erect, is being relieved by the other. The tail is, in fact, formed by elongated secondary plumes that normally hang down over the rump. As one bird approaches, the sitting bird leaves its nest and cocks its plumes; the mate replies by bowing and pecking at the ground. The pair pass one another quickly, the departing bird rapidly jerking its tail up and down.

Egg turning is always carried out immediately after the relieving bird reaches the nest. Turning the eggs is said to cease when the chicks start to chip. N. Tinbergen, in a discussion of gulls, postulates that this may be caused by the adult hearing the chipping, and that the sound counteracts the stimuli for turning, which is not resumed. The eggs are not left unattended for long, but when on one occasion the nest was left unoccupied, a Hooded Crow (*Corvus cornix*) approached within a few feet of the eggs and neither crane attacked it, although they were both nearby. For some reason, the crow flew off without raiding the nest.

On reaching the nest, the crane that takes over turns the eggs, and then looks round to observe the complete area of the marsh before settling down to incubate. Should there be any sign of movement, the bird becomes instantly watchful; when a Marsh Hawk (*Circus cyaneus*) quartered the bog, the crane stood up, although it quickly settled down again on the eggs after the possible danger had passed.

How does one understand, or begin to explain, the actions of the birds during this fascinating and intimate interlude at the nest? Some cranes have been observed to pick up bits of vegetation and throw it over their heads while approaching the nest and sometimes to trumpet.



As one bird approaches, the sitting mate leaves the nest and cocks its "tail" plumes.

Still displaying, bird goes off to feed, passing mate that will begin nest duty.

The Sandhill Crane of the Nearctic region is described by Lawrence Walkinshaw (*The Sandhill Cranes*) as "displaying his tertials high over his rump" when approaching the nest. ("Tertials," like the word "tail," as used above, is also a misnomer for the elongated secondaries.) He goes on to compare this behavior with a similar display by Common Cranes in the Detroit Zoo when they were approached by a pair of White-necked Cranes. The implication is that raising the feathers is a threat display.

In the case of the Common Crane we observed in Norway, it may well be that the raising of the secondaries was a threat response to the approach of the other bird. The approaching bird replies to the threat display by bowing and pecking at the ground. These movements have something of a submissive character, and may be designed to neutralize the threat. Bowing is reported as an element of the courtship display in the Japanese Crane by G. Stuart Keith (NATURAL HISTORY, February, 1962). Pecking at the ground may be some kind of displacement feeding activity.

The preening behavior we observed in the approaching bird may well be "displacement preening," as against "preening for its own sake," an activity reported in gulls by N. Tinbergen in *The Herring Gull's World*.

In view of these possible threat—or displacement—displays, it is difficult to understand why the approach of the Hooded Crow, mentioned above, did not create an alarm reaction in the crane at the nest, especially as crows are notorious egg eaters. Can we assume from this that crows do not usually steal cranes' eggs? It is difficult to say. Perhaps the eggs are too large

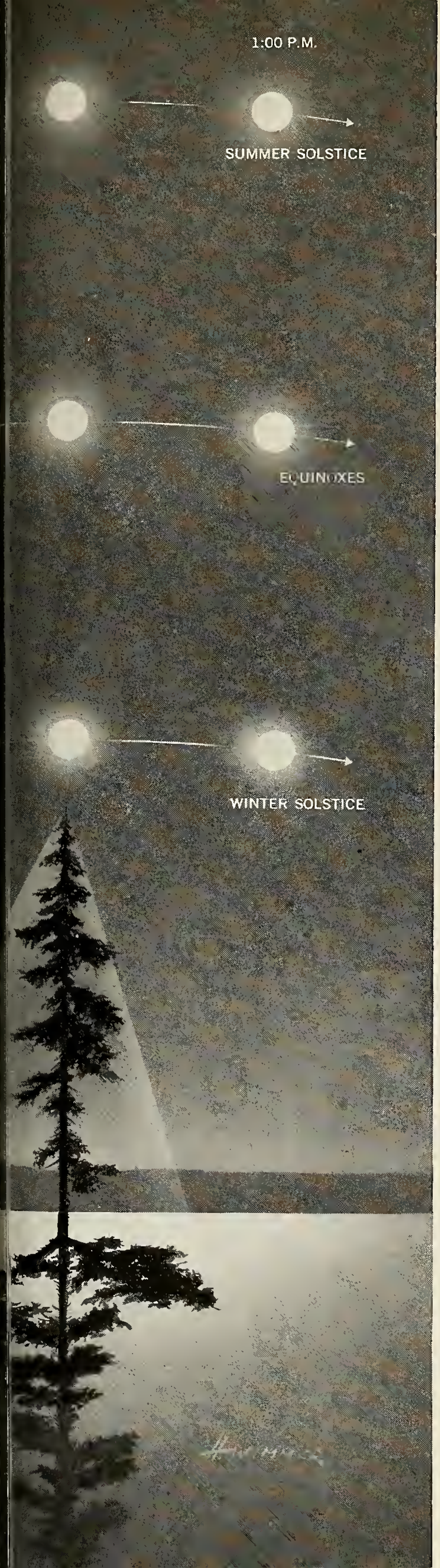
Returning bird turns the two eggs, a performance carried out by each crane.

for a crow to handle conveniently.

At one time during our observation, a raven flew close by, but the crane's reaction was slight and no threat display occurred. One observer reported in *British Birds* that he had actually seen a crow piercing an egg—although not carrying it off—while the crane was standing within thirty feet of the nest. On a few occasions one of the pair would run at a crow, hissing and with wings partly raised, but this has rarely been observed and is thought to be exceptional. In the majority of the cases that were observed, crows have not stimulated the threat display, and therefore no attack has followed.

Certainly our bird observations were speculative. But that in itself is one of the main reasons, I suspect, why so many engage in bird watching.

SKY REPORTER



Simple stick can be utilized for astronomical measurements

By Thomas D. Nicholson

The celestial calendar for the months of June and July (*page 37*) includes the annual notice that on June 21 at 3:33 P.M., EST, the sun arrives at the summer solstice, and summer begins in the Northern Hemisphere. At noon on June 21, the sun's shadow is the shortest of the year in the latitudes of the United States. There are several other interesting things about the sun's shadow that day. For example, it points its greatest distance to the south of west at sunrise and to the south of east at sunset, indicating that the sun rises and sets the greatest distance north of east and west on that date. Also, the sun is due east (its shadow pointing west) and due west (its shadow pointing east) closer to local apparent noon on June 21.

All of the above phenomena of the sun's shadow could be observed if you were familiar with one of the simplest of all astronomical instruments. the simple gnomon, or shadow stick—the basic component of a sundial. So ancient is this crude device that there is really no history concerning where or when it was first introduced or its application to early astronomical measurement. Yet it is so elementary that it might well have been used by the men first concerned with the measurement of time and direction on earth; it can also be used for sophisticated astronomical measurements.

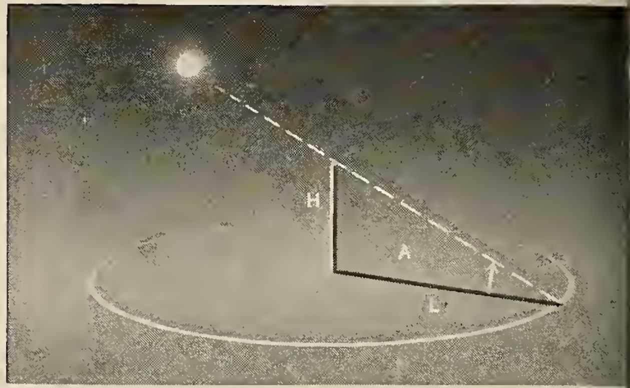
In its most primitive form, a shadow stick can be any object placed vertically in the ground. It need not be placed in that position deliberately; it can be a small tree, a sharply pointed rock, a stump, or any object with a clearly defined peak that casts a sharp shadow. It need not be precisely vertical, so long as the relationship between the height of the top and the length of the shadow it casts can be readily compared. It need not have any specific height. so long as its height is known or can be measured, and remains constant, although, for convenience, it should not be too high. To be reasonably useful it should be a thin rod, pole, or stick:

1. Between two and six feet high, depending on how much flat, level ground may surround it, for the higher it is the longer its shadow will be;
2. Firmly imbedded in the ground, so that it will remain upright in the same place;
3. Placed as nearly vertical as a simple plumb line will permit, so that the length of the shadow it casts, in relation to its height, may be conveniently measured from its base;
4. Either pointed or rounded at the top so that the distinctive, identifying point of the shadow cast may be located as accurately as possible.

Simple as it may appear to be. a shadow stick so erected can be used to identify the local meridian and all the points of the compass; to determine the dates of the solstices and equinoxes and the length of the solar year; to measure the

Illustration shows the changes in the sun's shadow—from one hour before noon to one hour after noon—at the time of the summer solstice, the equinoxes, and the winter solstice.

Direction of north–south line can be determined by bisecting angle of two shadows of equal length before and after noon.



Tangent of the sun's altitude at any time equals the ratio gnomon's height (H) to length of the shadow (L) it ca

obliquity of the ecliptic and the latitude of the place where the shadow stick is located; and to indicate daily the moment of local apparent noon.

Consider the ways in which the shadow of the stick, cast by the sun, will change during the day and during the year: on any one day, at about sunrise, the stick will cast a long shadow opposite to the direction of the rising sun. As the sun rises, the shadow cast by the stick will grow shorter and change direction. After noon, the shadow will continue to change position and grow longer as sunset approaches.

Note the exact position and length of the shadow cast hour by hour before noon and after noon and mark the ground accordingly. You might think this an effective way for telling the time by the length and direction of the sun's shadow. But if you should check the marks again in a few weeks at the same times before or after noon, you would find that both the length and direction of the shadow at a given hour have changed.

Thus—with one exception—the shadow of a gnomon cannot be used to tell the time of the day. That exception concerns the time each day when the shadow cast is shortest. Each day, this shadow would differ slightly from its length on previous days; but if you mark the *direction* of the shadow at the moment when it is shortest, you will note that on subsequent days the shortest shadow will point in the same direction. In other words, the noon sun bears due south from any place in the United States, and the stick indicates that moment by casting its shadow due north.

To identify the local meridian, simply mark the length of the shadow on the ground from the base of the stick to the tip of the shadow, at any moment an hour or two before noon. Using the length of this mark as a radius, draw a circle on the ground around the base of the stick. Some time after noon the tip of the lengthening shadow will touch this circle again; as it does, mark the position of the shadow. This line, and the line of the shadow marked in the morning, will form an angle with the vertex at the base of the gnomon. If you draw a line exactly bisecting that angle, the line will extend due north and south, marking the meridian. A perpendicular to this line will mark the east–west directions. By dividing the right angles formed by the north–south and east–west lines, all other points of the compass can be laid out easily.

With a meridian marked out, you can begin to record with accuracy how the length of the gnomon's shadow varies from day to day at noon. Suppose you had marked out the meridian in early June: mark the position of t shadow tip each day, at the moment the shadow points d north. From day to day, until June 21, this mark dra closer to the base of the shadow stick. After June 21, t marks appear progressively farther away. The short noonday shadow is cast on June 21, when the sun sta highest in the sky—the date of the summer solstice.

Continue to mark the position of the shadow tip at no daily (when it points exactly north); you will find t shadow is longest on December 21, the winter solstice.

Readers familiar with trigonometry will recognize t the ratio of the height of the stick to the length of t shadow is equal to the tangent of the altitude angle of sun. If this arithmetic is performed every day when t sun is on the meridian, the meridian line can be mark on the ground with a scale that shows the altitude an with the dates the sun cast that particular shadow; in ot words, an automatic calendar is created. A scale of t kind allows a more advanced use of this simple instrume

To find the dates of the equinoxes, you might sim observe the dates on which the shadow, at sunrise and sunset, is along the east–west line previously marked the ground. On these dates, the sun is on the celes equator, directly above the Equator on the earth. Read sun's noon altitude from the scale and subtract this va from 90°. The answer is the latitude of the gnomon. labeling the scale "zero degrees" at this point, the an indicated each noon thereafter will be the declination the sun north or south of the celestial equator.

Of course, the gnomon cannot operate on cloudy days modern innovation would be to plot vertically on a gr the various shadow lengths and directions that have b measured, using the date as a horizontal axis. A smo curve can be drawn through these points, and the miss observations can be read by "interpolation."

All of these observations can be carried out with other information than the length and direction of shadow cast by a stick and the height of the stick. W other information, the shadow stick could be used for ferent observations and measurements, including the eq tion of time, constructing an analemma on the grou (NATURAL HISTORY, October, 1962), the difference tween clock time and sundial time, and finding the lo tude of the gnomon.

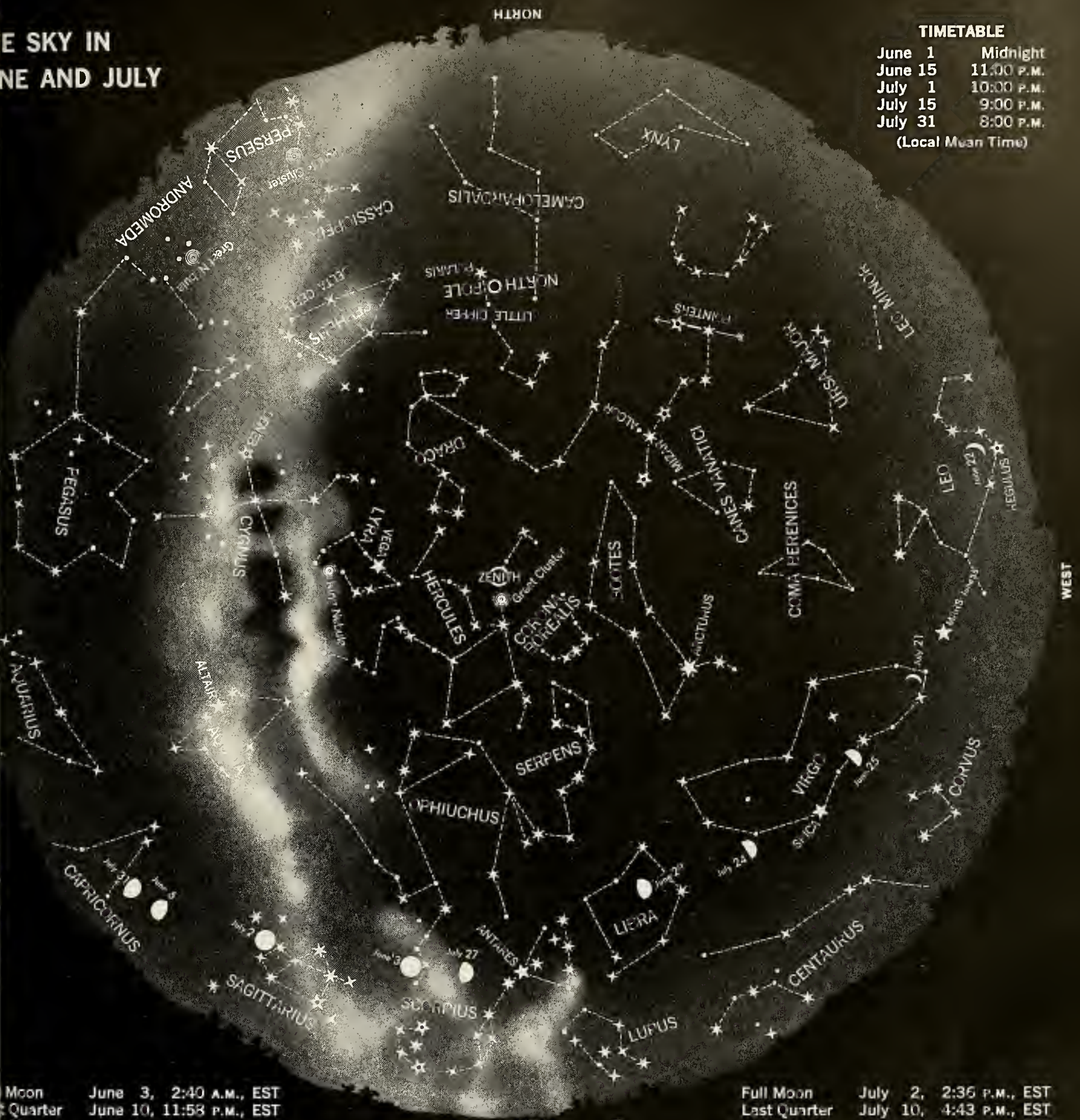
DR. NICHOLSON, the regular author of this column, is al Chairman of the AMERICAN MUSEUM-HAYDEN PLANETARIU

E SKY IN
NE AND JULY

TIMETABLE

June 1	Midnight
June 15	11:00 P.M.
July 1	10:00 P.M.
July 15	9:00 P.M.
July 31	8:00 P.M.

(Local Mean Time)



Moon	June 3, 2:40 A.M., EST
t Quarter	June 10, 11:58 P.M., EST
Moon	June 18, 3:09 P.M., EST
t Quarter	June 25, 8:22 A.M., EST

Full Moon	July 2, 2:36 P.M., EST
Last Quarter	July 10, 4:43 P.M., EST
New Moon	July 17, 11:30 P.M., EST
First Quarter	July 24, 2:00 P.M., EST

une 11-12: Saturn, about magnitude +1.4, rises on these rnings approximately three hours before the sun, and is up in the east by dawn. The moon, just past last quarter, ses Saturn from the 11th to the 12th.

une 15-16: The late crescent moon and Venus are near another in the morning sky, Venus to the left and below moon on the 15th; above and to the right on the 16th. junction is at 6:00 P.M., EST, on the 15th.

une 21: The sun arrives at the summer solstice, directly r the Tropic of Cancer, at 3:33 P.M., EST. This is the begin- of summer, and although this is the longest day of the r in the Northern Hemisphere, in the sense that the sun bove the horizon for the longest duration, it is not the date the earliest sunrise or the latest sunset. This year, the liest sunrise occurs on June 14, and the latest sunset on e 27.

une 30: Mercury is at greatest elongation (about 26°) east he sun; it may be seen as an evening star for several days ore and after this date.

uly 5: The earth is at aphelion, the greatest distance—approximately 94,448,000 miles—from the sun for the year.

After dominating the evening stars all winter and spring, Jupiter is in conjunction with the sun, and moves into the morning sky.

July 8: Saturn and the gibbous moon rise almost together about midnight. Over the next several hours the moon will appear to drift slowly to the left with respect to Saturn, passing closest to the planet about 2:00 A.M., EST, on the 9th.

July 12: Saturn is stationary in right ascension, and begins to move westward.

July 15-16: Venus is steadily drawing closer to the sun on its way toward superior conjunction, but can still be seen on these mornings near the late crescent moon, low in the east, to the left of the moon on the 15th; to the right on the 16th.

July 28: Mercury is at inferior conjunction, passing between earth and sun, and moves into the morning sky.

July 29: The Delta Aquarid meteor shower reaches maximum, but the full moon will interfere with observations. This is a rather broad stream, however, and some meteors may be seen for several weeks before and after maximum.

Mites on a Substrate

ating behavior, studied in glass cells, features "piggyback rides"

By Syd Radinovsky

MITES are nearly ubiquitous; they are found in every imaginable itat and ecological niche: in soil, vater (fresh-water ponds, lakes and ams, and even oceans), in hot ings—and in climates as diverse as se of the Arctic Circle and the iator. Some have even been found ting in aerial plankton. They are iropods belonging to the order rina. Aristotle first used the term *ri*, relating it to "very small things, mites." The acarines—along with it other living orders, which ude the better-known spiders, scor- is, and phalangids (daddy long-) and the lesser-known pseudo- pions, whip scorpions, microwhip pions, and the obscure solpugids ricinuleids—are all members of class Arachnida.

lites are either free living or para- . The free-living forms occur in iying debris, humus, or leaf litter, association with mosses and li- is, and in the rich topsoils of ds and forests. They are either daceous, phytophagous (plant ers), or saprophytic (feeders on iying or dead organic matter).

arasitic mites are found in and on ebrates and invertebrates alike. , rats, cats, birds, snakes, chick- dogs, insects, and man are all isitized by mites. Ectoparasitism is ifested in several ways. The para- may live on the surface of the host, er abrading it or causing the host cratch and thus abrade itself; the isite may then feed on the open s. It may also penetrate the epider- or outer cuticle of the host and directly on the living inner sur- tissues. Sometimes it remains on outside of the host, but by means its piercing-sucking mouthparts penetrate the surface skin and tissue fluid or blood. Endopara- mites invade the respiratory s of primates, seals, walruses, ro- s, birds, dogs, and insects.

omicrograph of adult female and mites. Large, elliptical forms in emale, below, are developing eggs.

Recently I have resumed work on the biology and behavior of *Leiodinychus krameri* (family Uropodidae), a mite of cosmopolitan distribution. It is found in damp, moldy, stored grain, in moss, and in decaying or rotten hay and grass. The abundance of this species, and the lack of biological and behavioral information about it, prompted research in three main areas: (1) the search for a suitable method of confining and rearing the tiny organism; (2) a study of the biology and development of the mite under various temperatures and relative humidities; and (3) a study of the mites' reproductive behavior.

BASICALLY, the following requirements must be met in the construction of rearing cells for acarines: (1) an escape-proof design; (2) adequate gas exchange between the rearing cell and the surrounding atmosphere; (3) absolute ease of observation and manipulation of test organisms; and (4) maintenance of a suitable nutritional substrate or means of introducing one.

I ran a series of tests with open-ended glass tubes. Open tubes provide adequate gas exchange with the surrounding air and permit feeding, observation, and manipulation of the test organisms, as well. The bottoms of the tubes were also open and embedded in a charcoal-yeast-plaster substrate. The plaster is a binding agent for the waste-absorbent charcoal and the nutritional yeast. (For humidity and temperature experiments, the tubes were placed in desiccators and stored in controlled-temperature cabinets, shown on page 40.)

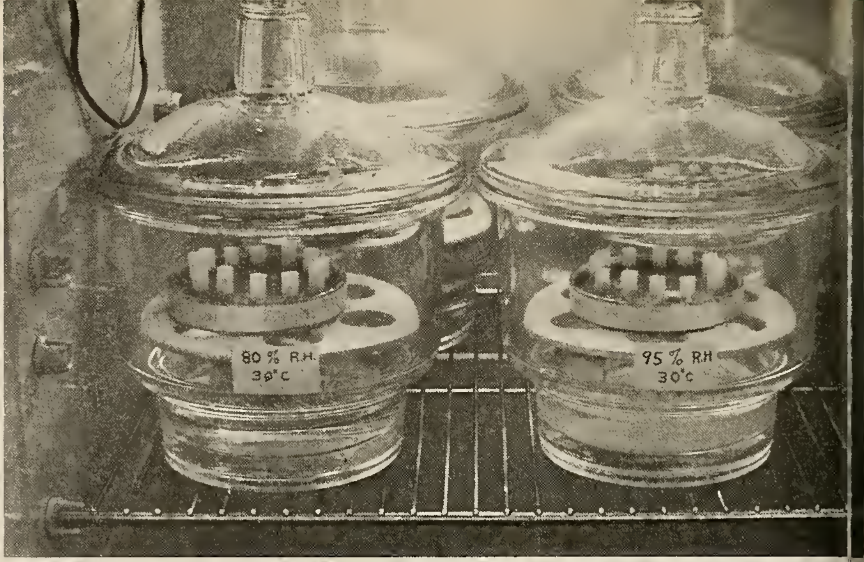
I applied a band of Fluon—a small-molecule liquid that hardens on drying—to the inner top rims of the tubes in an effort to produce a slippery surface, one the mites could not cling to or travel over. It appears that the size of the caruncle (the soft, sucker-like structure between the tarsal claws), or perhaps the size of the claws themselves, plays a significant role in the ability of the mites to traverse smooth surfaces. The mites picked out tiny imperfections inherent in the first application of Fluon. Additional coatings, however, covered the imperfections, and ultimately, successful confinement of the test organisms approached 100 per cent (at 20° C. and at all relative humidities).

During life history and behavioral studies, various stages of *L. krameri* climbed up the glass tubes only to lose traction at the Fluon barrier and drop down into the cell. Even when food was withheld at the usual feeding time and the drive to escape was strong, the mites could not climb out of the tubes.

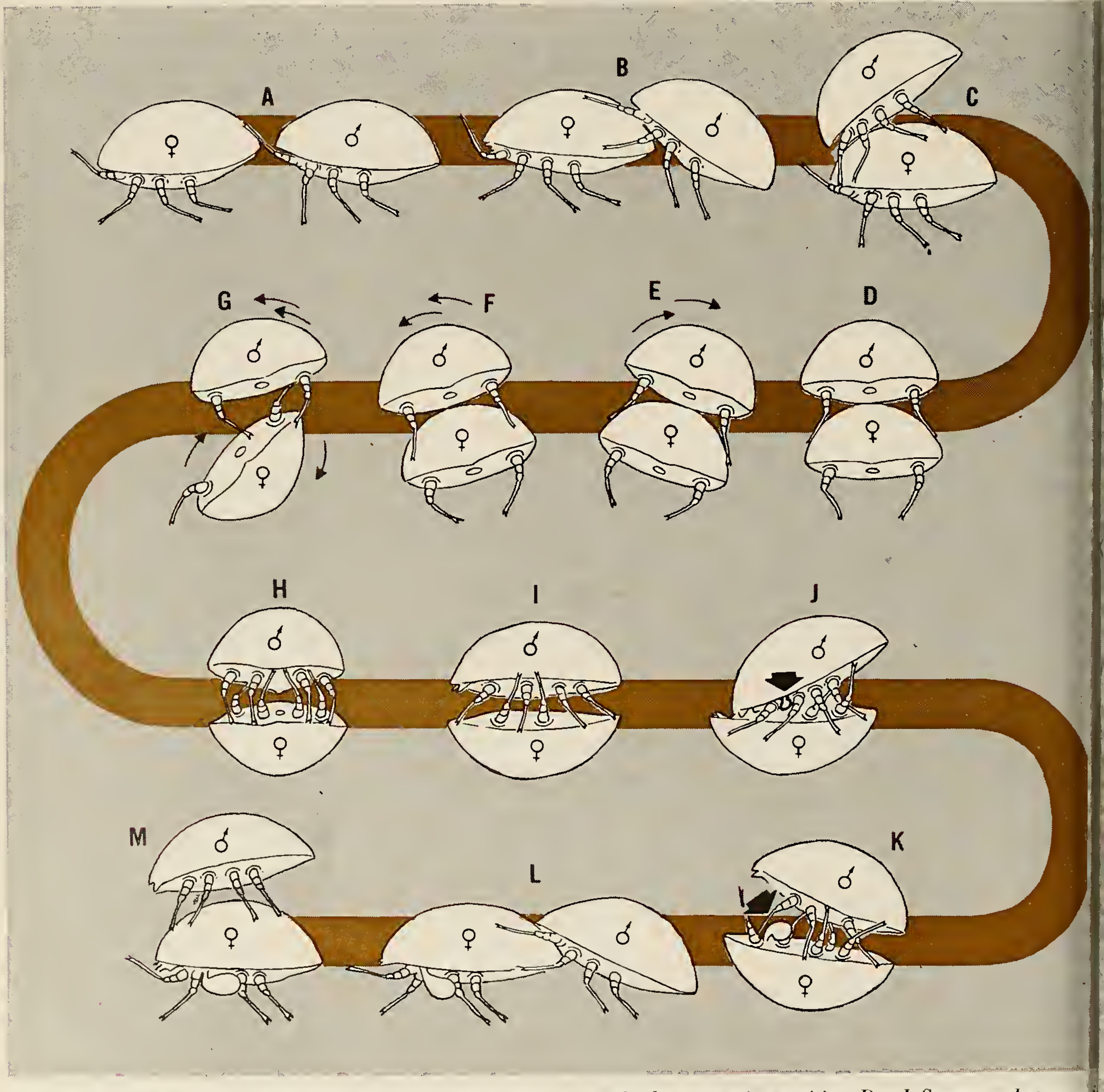
Having developed a successful method of open-cell containment, I reared *L. krameri* in the laboratory under different conditions of temperature and relative humidity to determine survival and developmental rates. Rearing to the adult stage was achieved only at temperatures between 20° and 30° C., and at humidities of 80 to 95 per cent.

Mites reared at the same relative humidity (95 per cent) but at different temperatures (20° and 30° C., respectively) showed a significant size difference, those reared at 20° being larger than those reared at 30°. Although there was a direct relationship between increased temperature and an increase in rate of development, apparently there was an inverse relationship between temperature increase and actual size; individuals that grew in a cold environment were larger than those in a warm one.

Mating behavior, which bears a strong resemblance to that of pseudoscorpions (NATURAL HISTORY, May, 1965), is here divided into three main phases: (1) the premating or exploratory phase; (2) the formation of a sperm packet by the male and the subsequent attachment of the packet to the female's epigynial shield (the sclerotized plate covering the genital opening); and (3) the assimilation of the sperm packet by the female and the postmating behavior of the male. The duration of the entire mating



Cells, above, are in a charcoal-yeast-plaster substrate. Trays are placed in temperature-controlled cabinet, right.



In mating behavior of Leiodinychus krameri, *male mounts female, A to C. He overturns her through a rocking motion and achieves mating position, D to I. Sperm packet, arro[w] i[s] affixed at J and K. At L and M he again climbs atop fem[ale]*

ocess varies in different environ-
ental conditions of temperature and
imidity, and may be affected by the
nount of artificial light. In 56 obser-
tions of actual mating, total time
ried from 45 minutes to 8 hours.

The premating behavior of *L. kra-*
eri follows certain typical patterns,
shown on the page at left. The male
wly approaches the usually inactive
nale and probes her with his fore-
gs. He then quickly climbs upon her
rsum, actively moving his mouth-
rts and forelegs over her body.
entually the male attempts to turn
e female over; the female, however,
ually resists at this point, and often
nporarily escapes his persistent ad-
nces by throwing him off and mov-
g quickly away. After struggling
veral minutes—the time varies con-
lerably—the male turns the female
er, mounts her, and they assume a
nter-to-venter position. The actual
erturning of the female is accom-
shed by sudden, violent, lateral rock-
g movements of the male as he
nly grasps the female with all four
irs of legs.

NEWLY emerged adults, paired and placed in rearing cells, did not
nibit premating behavior until eight
ten hours had elapsed from the time
emergence. However, males older
n ten hours introduced into rearing
ls harboring young adult females
mediately showed typical premating
terns. Indeed, one adult male, iso-
ed in a rearing cell for almost three
nths and then placed in another cell
h an adult female, actually formed
perm packet in less than a minute.
Often, adult males were observed
nbing on adult females that were in
process of emerging and were still
gely enclosed in their exuviae (the
n being cast or molted). Older
ılt females introduced into cells
ntaining newly emerged males
wed active interest in them, but the
les did not respond to the advances
the females. In general, however,
older male was the aggressor, the
nale remaining passive and often
ibiting a strong aversion to the
e's advances.

The second step in mating—the for-
ion of sperm packets—was ob-
ved on several occasions. Typically,
occurs when the male is in a
ter-to-venter position with the fe-
e, although a sperm packet is
netimes formed without any physi-

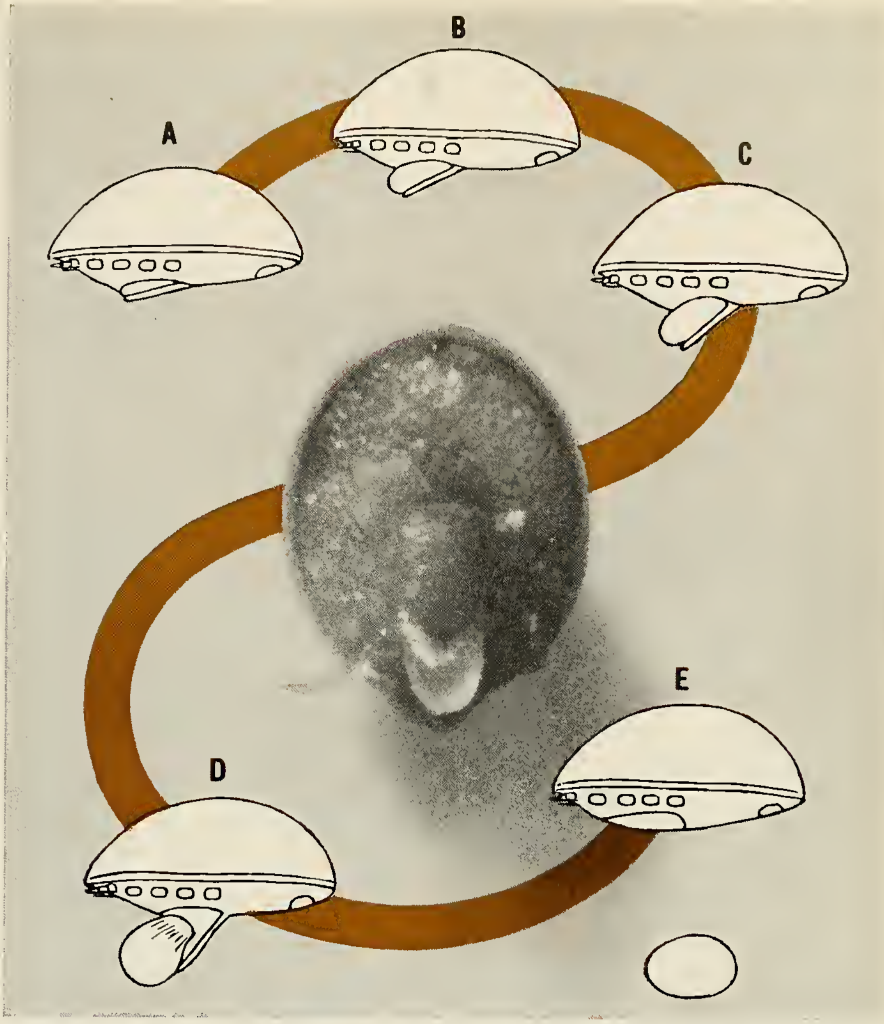
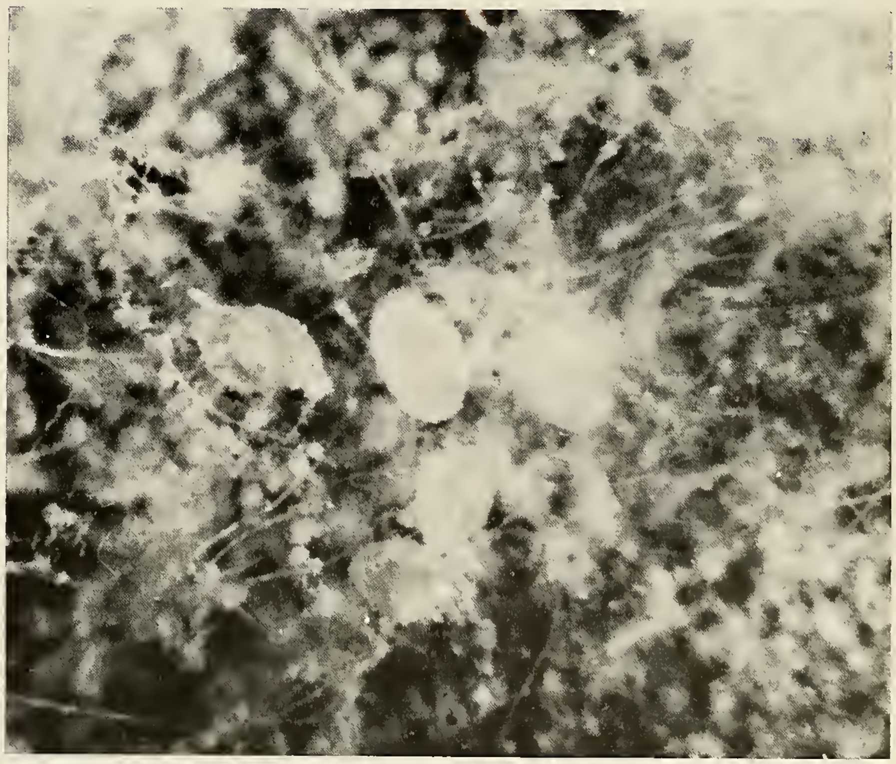


Diagram of egg laying, above, shows the movement of the epigynial shield. Note that shield is posteriorly hinged. The mite is facing left in the drawings.

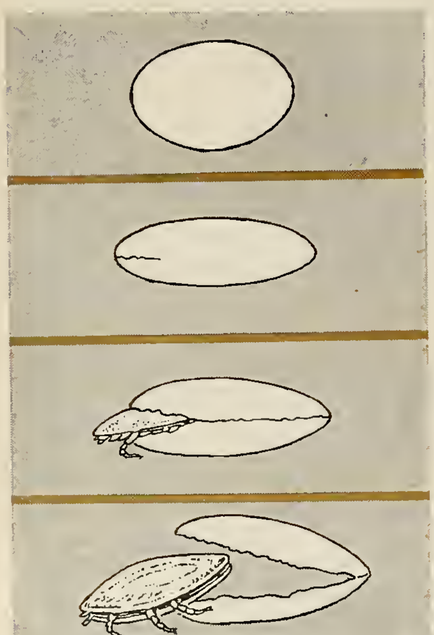


Mite eggs after deposition on cell substrate. The fibrous material is mold, preferred as an egg site by the mites because it has a cushioning quality.

cal contact with the female. Initially, a milky-white bubble is exuded from the male genital opening, growing larger and larger until it reaches a diameter of approximately 210 microns. Full size may be reached in about a minute. The liquid sphere then hardens, or coagulates, into a round, saclike structure that is transferred to the chelicerae, the specialized feeding structures on the jaw. In this transfer the legs presumably play a major role, although the positions of the mating pairs made the observance of this process impossible. The anterior portion of the female's epigynial shield has hooklike structures onto which the male affixes the sperm packet. The packet itself has a terminal opening through which the sperm may escape.

The sperm are gradually assimilated by the female, the packet becoming smaller and smaller. During the period of sperm assimilation, when the female has righted herself, the male assumes a position atop the female. After mating, the female may be active or stationary, but she continues to carry her mate, which tenaciously holds on to her dorsum. No adult male was ever observed riding on the dorsum of a female that lacked the sperm packet. Complete assimilation lasted from 40 minutes to 7¼ hours.

In one instance, a newly emerged adult female was found with a partially assimilated sperm packet and



Typical hatching procedure of a mite egg is shown above. Cover surrounding the egg first ruptures. Then the larva uses its forelegs to extricate itself.

with the male still riding upon her dorsum. Present in the same cell was an older female, also bearing a partially assimilated sperm packet. Inasmuch as only one male was present, it is apparent that the male of *L. krameri* is able to form more than one sperm packet in a matter of hours.

The best example of this ability was found in another situation. Here a newly emerged adult female was placed in a cell containing a virgin male that had emerged 100 days earlier. In a space of less than 12 hours, he had formed 3 sperm packets.

I also observed competition of males for females by introducing an adult male into a cell containing an adult pair. No unusual behavior of any of the three individuals occurred during the first hour. Then, 1¼ hours after the introduction of the new male, the original male began to ride on the female's dorsum. After a few minutes, the second male exhibited aggressiveness and forced the incumbent male off the female. The aggressive male then rode for several minutes, after which the pair mated. Within 2½ minutes a sperm packet was found attached to the female's epigynial shield, and the aggressive male resumed his position on her dorsum. The original male made no attempt to regain possession of the female.

At 20° C. and 95 per cent relative humidity, adult females began laying eggs not earlier than 14 days after mating, and continued to do so for a period up to 101 days after the initial pairing of adults. Not more than one egg was laid per day, except on rare occasions when two eggs were deposited during a 24-hour period. Generally, eggs were laid less frequently than one per day. Examination of many adult females mounted on slides revealed one or two developing eggs, as shown on page 38. On no occasion were more than two eggs seen in an adult female.

As the fertilized egg passed through the genital opening in the laying process, the posteriorly hinged epigynial shield opened anteriorly and outwardly like a trap door. The egg was forced to elongate somewhat as it passed through the narrow opening, but it immediately resumed its oval shape after oviposition had taken place. Eggs were deposited singly and usually were cushioned between spaces in mold or in soft, flaky grooves of

the plaster-charcoal-yeast substra
Where such preferred niches were n
available, the eggs were mere
dropped randomly on the substra
No parental care was exhibited
either parent.

In 24 to 48 hours after ovipositio
depending on environmental con
tions, the eggs began to lose their ov
form and became progressively fl
tened dorsoventrally. Phase-contr
microscopy shows the embryonic a
pendages to be well developed.

Hatching usually begins with t
appearance of a rupture in the a
terior portion of the chorion, t
membranous envelope covering ea
egg. Shortly afterward, the forelegs
the larva emerge and initial brea
through is brought about throu
their movements. The larva then
creases in size by swallowing eith
fluid or air. The typical hatching pr
cedure in *L. krameri* is shown in t
diagram below left.

While oviparity, the production
eggs that hatch outside the body of t
parent, is common in *L. krameri*, so
ovoviviparity, the production of eg
that hatch within the parent's bo
(the young larvae escaping from t
eggs at the moment of deposition).
times only eggs or larvae were fou
in individual cells, and at other tim
eggs and larvae were found togeth
This fact raises the question wheth
the mites lay eggs when conditions a
less than optimal (the eggs, perha
being better equipped to cope w
suboptimal conditions) and then
posit living young when conditio
are optimal. Eggs appear to be mo
resistant to unfavorable conditio
larvae will succumb more quickly th
eggs to, say, a combination of low te
perature and low humidity.

The capacity for both oviparity a
ovoviviparity undoubtedly has s
vival value to this persistent speci
the female responding physiologica
to environmental conditions and th
producing eggs or living larvae
cordingly. The extent to which su
a faculty is used by other acarines
as yet unknown. Considering t
acarologists (those who study
acarines) estimate that there may
more than a million species of mi
collection of information on even
smallest fraction of them is an en
mous task. The life of a species i
laboratory rearing cell is, moreov
only a first tentative step in the di
tion of understanding its total biolo

The variety found in a group of animals that may include more than a million species is considerable, indeed. A modest mite sampler is shown here. The "velvet" mite, below, one of the largest mites known, reaches a length of half an inch. Smaller, but still visible with the naked eye, the water mites, above right, are often seen in lakes and ponds. The species encircled in the microscopic fields are extremely minute forms: those on the left are terrestrial, and the one on the right is aquatic.

Colorful Barcelos pottery roosters are sold in shops all over the world, and are popular with the Portuguese and with most tourists as well.

Portugal's greatest living folk artist, Rosa Ramalho, who makes her figures with great originality, is not rigidly bound by traditional forms.

Folk Art Is A Link With Roman Past

POTTERY OF BARCELOS

by Nancy Flowers

A bishop of Braga, reporting on the state of his diocese at the Council of Trent in the sixteenth century, thus addressed the Pope: "Only at Prado [Barcelos, in northern Portugal] do I have some priests who do not sin, but those are made of clay, and should Your Holiness wish I can send you a few." This bit of irony not only tells us something about priestly shortcomings in Portugal at that time, but also shows that at that date the pottery figures of Barcelos were already well known. Probably then, as today, they depicted men and animals, angels, devils and monsters, and hybrid figures half-man, half-beast, all drawn from folk imagination and deeply rooted in an almost forgotten belief in primitive magic.

It is indeed probable that pottery has been made at Barcelos for many centuries, if only because of the abundance of clay found in the region and still worked by methods that have scarcely changed down the years. The potter himself brings the clay from the beds by oxcart. He spreads the load in his yard and drives the oxen round and round over it to grind it fine. He mixes the clay with water, kneads and pounds it by hand, and bakes his pots in ovens similar to those excavated at sites occupied by the Romans.

The principal manufacture of the Barcelos potters is common household ware—waterpots and cooking pots, basins and colanders—in shapes that, too, have changed little since Roman times. The ware is of red clay decorated with white clay, or vice versa, and glazed with a lead glaze that has red or white clay dissolved in it. Women or boys decorate the pieces with a stick or a feather dipped in clay. Many of the linear motifs used are the same as those found on pottery from the nearby Roman site at Citânia de Briteiros, such as the "wave and dot" pattern. The classic swastika and varying representations of the sun are also common.

Still more archaic and curious, however, are the small clay figures that Barcelos potters model. These are either turned out from molds, often handed down from father to son, with hand-shaped details applied before baking, or are modeled entirely by hand. Sometimes whole scenes from daily life are created, comprising numerous figures ob-

Rosa Ramalho is shown in outdoor workroom, watched by grandchildren and great-grandchildren. She often converses with her visitors here.

Little priest with book in ha[nd] has tail protruding from casso[ck]

served with peasant humor. They show, often satirically, bread baking, washing clothes by the riverbank, pig feeding, grape treading, shoemaking, and revelers at a fair. Religious themes are also used; two popular ones are the Nativity and the *Alminhas*, or souls in purgatory.

Animal figures are often given the form of whistles, or are presented as toothpick holders—a simple matter of piercing a few holes. In *Portugal, a Book of Folkways,* Rodney Gallop wrote: "In form some of these whistles are astonishingly archaic. A bird with little ones linked to it by earthenware loops reproduces almost exactly a Graeco-Roman toy in the National Museum at Athens. A horse which might have been copied from that of Troy, a bull of Minoan aspect and many other figures may be compared not only with the modern clay figures made at Seville, in the Balearics and in Mexico, but also with ancient ones from Cyprus, Crete, and the Crimea."

The snake is common, as is the *sardão*, a kind of lizard that is said to persecute women and warn men of danger. The pig is usually shown as a sacrificed animal, for pig slaughtering in rural Portugal is a ceremonial occasion. Dr. José Leite de Vasconcelos believes that the principal deity of the ancient Lusitanians was a pig god. Prehistoric statues of pigs or boars have been found at many places in the Iberian Peninsula, the best-known one in Portugal being the "Porca de Murça," a stone figure of a sow at Murça in Tras-os-Montes Province. The representation of the ox is oriental in character, although it is modeled after a local breed whose great, lyre-shaped horns and long-lashed eyes give them an antique air, especially when they are brought to market with bouquets of wildflowers tied to their horns.

The Regional Museum of Ceramics at Barcelos houses a complete collection of these figures, which, although modeled only a few years ago, are linked in spirit to the remote past and show unchanging ways of life. If no figured pieces survive from very early times, this, according to Dr. Eugénio Lapa Carneiro, Curator of the museum, may well be because the products of the Barcelos potters were considered too crude for the houses of the nobility. Sold to peasants at country fairs, they were used, broken, and thrown away. Thus, the oldest that have been preserved date from the nineteenth century.

This fascinating folk art seems to be in danger of dying out. Already the most popular of Barcelos animal figures, the rooster, has become co[m]mercialized. Until about ten ye[ars] ago the potters made the roosters [in] molds, but with hand-modeled [...] tails. The figures have become m[ore] and more stylized in recent yea[rs], and are now turned out by the th[ou]sands. Jaunty, brightly painted "P[or]tuguese cocks" are found in gift sh[ops] all over the world, and there is har[dly] a tourist coming to Portugal w[ho] does not take one or more home.

The people of Barcelos expl[ain] the rooster's local popularity by [a] legend. One day, the story goes, th[ere] passed through Barcelos a group [of] pilgrims on their way to the shr[ine] of St. James at Santiago de Comp[os]tela. They stopped at a tavern on [the] main street of the town, but as th[ey] were carrying with them their o[wn]

Three wise men stand in foreground of a crèche containing other figures.

provision of roast chickens and sausages, they spent little money at the nn. The landlord, a mean character, esented this and resolved to take evenge on the travelers. Craftily he slipped a silver spoon into the scrip of one of the pilgrims, and then denounced him to the authorities. When a search was made and the spoon ound, the man was condemned to be hanged for the theft. The frightened but pious pilgrim fell to his knees and prayed to St. James for aid. Then, in a flash of saint-given inspiration the man jumped to his feet, snatched a oast chicken from his bag, and cried to his accusers: "It is as true that I am nnocent as that this cock will crow!" Whereupon, to the amazement and error of all present, the bird rose, flapped his plucked wings, and gave out a lusty "cock-a-doodle-doo!"

In a Barcelos square stands an ncient, carved stone cross that eems to commemorate this miraculous event, for on one side it shows man hanging from a noose, with t. James supporting him from below, and above his head is the figure of a crowing cock.

At present only a very few potters f Barcelos model clay figures in the raditional way. One of these is a 6-year-old woman, Rosa Ramalho,

Rosa's granddaughter Julia shows promise as an inventive artist, but is here seen adding the finishing touches to a conventional rooster.

whose talent and imagination are bringing her recognition as Portugal's greatest living folk artist. Dr. Lapa Carneiro says of Rosa: "She models the traditional figures and repeats them, but while other potters repeat figures mechanically, hers have the breath of life, and she never makes two exactly alike. Besides making the usual figures, she invents and creates new ones, but always works within the form and spirit of the tradition. Her talent is exceptional."

Rosa Ramalho is a tiny, bright-eyed old lady, warm-hearted and quick of wit and temper, who lives in a vine-covered stone cottage near the village of São Martinho de Galegos. With her live several of her grandchildren and seven of her sixteen great-grandchildren. All day she sits at her outdoor workbench, her fingers busy with the clay as she directs her household, scolds the great-grandchildren, or chats with the visitors that her recent fame has brought.

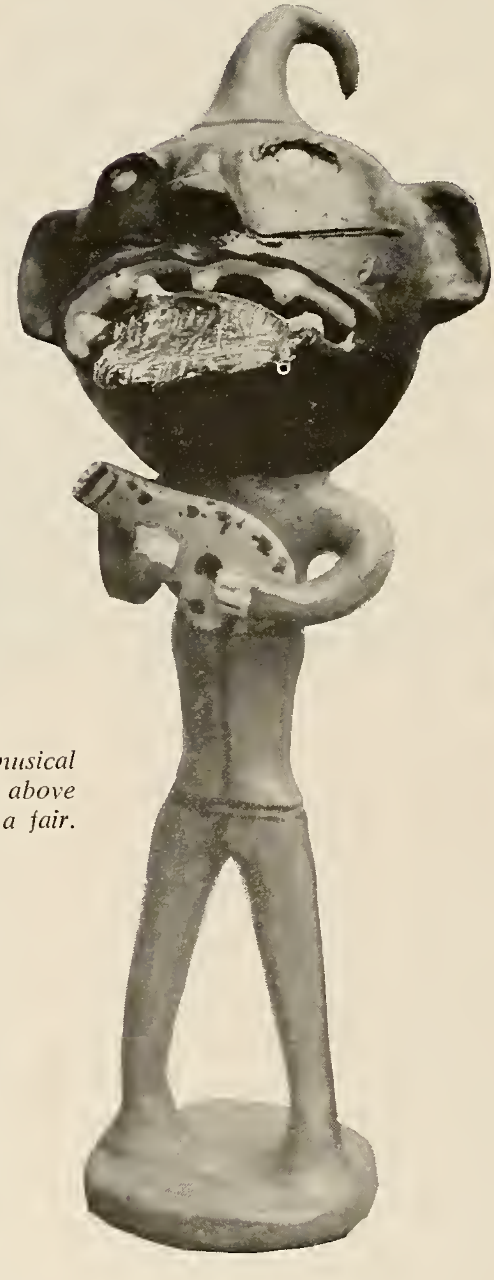
She molds her figures from white clay, sometimes glazing them uncolored, at times baking them unglazed and then painting them with color that she grinds and mixes herself. She bakes them in a primitive oven that looks like little more than a shapeless heap of bricks.

Rosa Ramalho prefers human figures to animal, and the latter are mostly anthropomorphic. On the shoulder of an upright horse-headed figure playing a guitar sits a little gnomelike figure also playing a guitar. Her Christ figures are angular and have a Romanesque feeling. Her

devils are jocular, with ballooning heads, toothy grins, and long, sinuous tails. Sometimes her figures suggest childhood nightmares, as when she places a dove atop a candlestick up which snakes undulate. Sometimes they are mischievous, as her figures of demure little priests with book in hand who—shades of the good bishop of Braga—have embryo tails protruding from their cassocks.

Rosa's father was a shoemak and her mother worked in the fiel When a little girl, Rosa, like the oth children, played at making figur out of clay. She never went to scho When she was ten she went to wo for a neighbor, a woman who ma little pottery baskets, and earned few pennies a day. (Here Rosa sho how she rolled the damp clay in long, thin sausages and how wi these her neighbor "wove" the lit baskets.) When she was in her tee she married a miller, and for the ne fifty years did no more modelir She bore seven children, of whc

Wearing masks and carrying musical instruments, grotesque figures, above and at right, are revelers at a fair.



Upright, horse-headed figures, right, are playing guitars; on their backs are humans, also playing instruments.

ɔur lived. She drove the miller's donɛy, loaded with sacks of flour, up ıe steep, rocky path from the water ıill to the village. Her children grew p, and she had grandchildren. They, ı their turn, grew up, and she had reat-grandchildren. It was a hard fe. As she puts it in vivid metaphor: During those years, I ate live rats."

Nine years ago her husband died, ıd Rosa says, simply: "As we had) live, I turned to the clay again." he modeled small figures, baked and ɔlored them, as she had seen the ther potters do. When her fingers ɔt into the clay, her imagination ran free. She took her *bonecos* down to the market to sell, and among her first customers was a painter from Oporto who recognized her talent.

Rosa takes in her stride the acclaim that has lately come to her. A short time ago she appeared on television, with great success. When the mayor of Cascais, a resort town near Lisbon, invited her to bring her *bonecos* to a folk art fair, she enjoyed the excursion hugely. Once a postcard came to her from France. As she cannot read or write, she asked the "Senhor Doutor" (Dr. Carneiro) to read it to her. He told her it was from a famous artist called Picasso, who also made things out of clay and who said nice things about her work. The postcard lay around on her workbench for a time, and then one of the smallest great-grandchildren took it to play with, and it was torn up.

King David sits on throne and holds rooster, left, and above is a figure that is example of broad folk humor.

Boy leads Minho oxen at cattle fair in Barcelos. Cattle wear bouquets on their heads, and are reminiscent of garlanded oxen of ancient Rome.

*Monkey is chained to post, weepi[n]
with paw on head of a monkey-chi[ld]*

*Household pottery is displayed at t[he]
weekly market that is held in tow[n]*

Although Rosa Ramalho wor[ks] within tradition, she is far from bei[ng] rigidly bound by it. A reporter wr[it]ing an article for a local newspap[er] asked her why she showed St. Anth[o]ny bearded in her figures, while t[he] church statues show him beardle[ss]. "Because I like men with beards," she replied. When I last paid her [a] visit, I remarked on a series she h[ad] just finished of she-monkeys chain[ed] to a post and weeping, some with o[ne] paw on the head of a monkey-ch[ild] that also wept. The animals we[re] pathetic and human. I asked her w[hy] she made them. "Because it is ve[ry] sad to be a captive," she said, "ev[en] if you are a monkey. As the sayi[ng] goes, 'Even the Christ Child would[n't] want to be shut up.' "

Rosa Ramalho is an original arti[st] and in her hands tradition lives. T[he] fear that it may die with her is allay[ed] by the knowledge that she is teachi[ng] her craft to her granddaughter Jul[ia] who shows promise of having inhe[r]ited her talent and her imagination

About the Authors

Dr. Georges Condominas, a Eurasian, was born in Vietnam and received his secondary school education in Paris. In addition to a law degree, which he earned in Hanoi after returning to Indochina, he holds a *diplôme* from the Ecole Pratique des Hautes Etudes, a school of the Sorbonne where he is now Director of Studies. Dr. Condominas was a visiting professor in anthropology at Columbia and Yale in 1963, and again at Yale in 1965. His article was translated from the French by Victoria Bordaz.

The author of "The Springbok," Dr. R. C. Bigalke, has worked as a game biologist in the large and remote Etosha Game Park in South-West Africa. He was also, for six years, Director of the McGregor Museum in Kimberley, South Africa. During this period, he spent whatever time he could spare watching springboks, both in the vicinity of Kimberley and in the Kalahari region to the west. Dr. Bigalke is presently Principal Research Officer for the province of Natal in South Africa.

Paul Mason Tilden, who wrote "Singular Metal from Cinnabar," has an extensive background in magazine and newspaper work and is currently the editor of a national conservation magazine published in Washington, D.C. He estimates that he has been an amateur mineralogist and geologist for twenty years. Mr. Tilden, originally a New Englander, now makes his home in Arlington, Va.

James Hancock, the author of "Nesting Observation," is an amateur ornithologist who is on the financial committee of the International Ornithological Union meeting that will shortly convene in Oxford, England. An Englishman, he is also a board member of the Royal Society for the Protection of Birds. Mr. Hancock is associated with the London office of Castrol Oil, Ltd.

"Mites on a Substrate" was written by Dr. Syd Radinovsky, an associate professor in zoology and entomology at Millersville State College in Pennsylvania. His article reflects a continuing interest in acarines, an interest he is also pursuing at the International Acarology Conference now under way in London. Dr. Radinovsky works, in addition, on the biology and behavior of marine invertebrates and terrestrial hermit crabs.

The article on Portuguese folk pottery was written by Nancy Flowers, a free-lance writer and photographer who often contributes to Natural History. Raised in Portugal, Miss Flowers is a world traveler who is presently on her third trip to Brazil, where she is working on a book about a child in the Amazon. Her photographic work is primarily devoted to sociological and ethnological subjects.

California's high country

By William H. Carr and Lewis Wayne Walker

History of the Sierra Nevada. by Francis P. Farquhar. *University of California Press, $10.00; 262 pp., illus.* John Muir and the Sierra Club: The Battle for Yosemite, by Holway R. Jones. *Sierra Club Books, $10.00; 207 pp., illus.*

Persons acquainted with the facts surrounding the establishment of Yosemite National Park associate this accomplishment with the name of the Sierra Club of California, and rightly so. This group of dedicated men, under the guidance of John Muir, played a vital part in the eventual delineation of the actual boundaries of the park as we know it today. By the same token, when one thinks of the Sierra Club, one recalls the name of Francis P. Farquhar, an outstanding conservation leader who has been closely connected with the development of the organization for many years. It is fitting that two books, one on the Sierra Nevada and the other on the Sierra Club and Yosemite, should be reviewed together.

In the *History of the Sierra Nevada* Francis P. Farquhar has succeeded in skillfully blending his own research and observations with those of others to evoke a beautifully rounded account of one of the world's great scenic regions. With competence born of deep affection for, and hard-won knowledge of, the mountains, he has produced an outstandingly satisfactory work that will stand the test of time as *the* book to read about California's superlative high country. (In saying this, we do not for a moment discount the significance of the writings of John Muir, Clarence King, or other appreciative and well-informed chroniclers.) Careful documentation, a good index, and an apt selection of illustrations and maps complement the text.

Commencing with a brief geologic description of the Sierra and a review of the flora and fauna, the author proceeds rapidly to his principal objective: to deal with "human experiences in the Sierra Nevada from the time the Spaniards first saw it to the present." The initial surveyors of the region are all mentioned here, their often heroic exploits delineated with both restraint and excitement. The stubborn mountain men who pushed westward in pursuit of beaver skins, resolutely facing hazards offered by difficult terrain and severe weather, are present, too. These are names that quicken the pulse of persons interested in "the opening of the West"—Kit Carson, Jedediah Smith, Joseph Walker, Zenas Leonard, and other adventurers. Immigrants following hard on the heels of the first explorers are described with the aid of well-chosen source material gracefully interwoven by the genius of a talented storyteller. And nowhere does Farquhar lose sight of the splendor of the mountains.

Of course, the story of the occupation of Yosemite has been told many times, but never more effectively.

There is a fine résumé of the struggle to establish national parks and forests in the Sierra, and the chapter "The Sierra Club and the High Sierra" focuses somewhat on these struggles. Farquhar himself has played a prominent role in many of these contests between conservationists and exploiters, yet he modestly gives the credit to others.

This book will be savored alike by those who are familiar with the scenes described and those who are not.

Holway R. Jones, in the preface of his work, *John Muir and the Sierra Club*, says, "This book begins by tracing the early development of Yosemite as a background for the founding of the Sierra Club two years after the establishment of the national park. It ends with the unsuccessful fight for Hetch Hetchy's preservation, the death of John Muir and the establishment of a new federal agency to protect the nation's wilderness parks." Jones fulfills those objectives. His book is a long, well-researched, and well-written document of historical value to all conservationists, land developers, and park managers. Although its approach is scholarly, it is written with much humor and warmth.

Jones writes that in the early phases of his work "Francis Farquhar was my godfather and adviser . . . without his assistance the project could never have gotten off the ground." Dr. Farquhar has every right to be proud of his protégé. Here is the detailed account of the fight to preserve Yosemite—through lobbying in the California State Capitol and in Washington, endless propagandizing actions and counteractions, and efforts to rally the "right people" to the cause of setting aside one of America's great national parks for the perpetual use and enjoyment of all the people.

More than half the book is devoted to an even more comprehensive description of the struggles to save the neighboring Hetch Hetchy Valley—once not unlike Yosemite—from would-be despoilers. Unhappily those efforts did not succeed and the Hetch Hetchy Dam was built to

urnish water for San Francisco and ther areas. To the investigative-minded eader, this is a particularly satisfying ook. Almost every wide-margined page as small-type, side-column references. 'here is also an extensive appendix, ›und bibliographic notes, and an index.

'illiam H. Carr is Founder and Director 'meritus of the Arizona-Sonora Desert luseum in Tucson; Lewis Wayne Walk-ʳ is the museum's Associate Director.

HE HUNGRY PLANET, by Georg Borg-rom. *The Macmillan Co., $7.95; 487 ɒ., illus.*

THIS book is a fascinating and authoritative analysis of one of the major ıreats to the future of mankind, the ıortage of food for a rapidly growing orld population. It warns that "the com-on battle against starvation, disease, ıd misery, and above all against ignor-ıce, requires a radical change in the ›als of world science." The author, eorg Borgstrom, Professor of Food :ience at Michigan State University, ›nvincingly demonstrates that "man reatens to deprive himself of a future ʳ refusing to recognize his predica-ent." The book will be of particular terest to the readers of NATURAL HIS-›RY because it deals with a major and mplex biological problem from a oad ecological approach.

It is now widely recognized that the ›rld's population is growing every three ars by the equivalent of the entire ›pulation of the United States, and that ɜ per capita production of food is de-ɜasing in the majority of underdevel-ed countries. Less appreciated is that vestock and domestic animals repre-nt a living mass weighing five times as ıch as that of the total human race, the uivalent of an additional 15 billion ople." Borgstrom calculates that on s basis the North American continent "exerting a population pressure on its ınt production corresponding to that of ›re than two billion people," even ›ugh the human population is not ıch over 200 million. He emphasizes ıt in Latin America and India the dis-›pancy is still greater, even without :ing into account the much larger wild ımal population. Furthermore, the ›blem is compounded in countries such India, where it is estimated that half of · food produced for man and domestic ımals is destroyed in the field or dur-, storage by insects, rodents, monkeys, l other wild animals.

n a chapter entitled "Ghost Acreage." ·gstrom calculates the farmland neces-y to produce for each country an ount of animal protein equivalent to t now obtained through fisheries. ost acreage ranges from an additional

one third of the tilled land in several countries of Europe to one and a third in Israel and one and a half in Japan. The book discusses in considerable detail how fisheries can make a much greater contribution to world food supplies.

Chapters describing the biological nature of the world food problem are followed by excellent analyses of the specific food ecology of various areas of the world. The chapter on "United States Food Surpluses" is appropriately subtitled "A Brief Episode," since U.S. food surpluses are already proving inadequate to the goals of the U.S. government's Food For Peace program.

The text is well illustrated with original graphs and tabulations, and a short but useful index is provided. Although the brief reference to endemic goiter gives the erroneous impression that vitamin A deficiency is an important etiological factor, and that the pulmonary disease emphysema is due to coalesced alveoli and not "a kind of slime accumulation in the lungs," both factual and typographical errors are pleasingly few.

In describing a major dilemma of modern man in biological terms, Borgstrom has shown both originality and imagination. The book will be informative and stimulating to all who are interested in the future of life on this planet, particularly that of man.

Nevin S. Scrimshaw
Massachusetts Institute of Technology

Biology: The Science of Life, by Karl von Frisch. *Harper & Row, $12.95; 516 pp., illus.*

Karl von Frisch, one of the great biologists of our time, shares with us in this book the treasure of knowledge and wisdom acquired during a productive life spent in the intimate company of living organisms. He is known to every biologist as the discoverer and ingenious interpreter of the "language of the bees," but this achievement is merely the culmination of a much broader search into the problems of comparative physiology of animals.

The major subdivisions of the book are: cells, tissues, organs and their functions, adaptations to environment, interrelations among organisms, reproduction, development, heredity, and evolution. The animals fare better than the plants, but there is a substantial coverage of plant structure and function. One asset of the book is the balanced treatment of invertebrates and vertebrates in every chapter. However, this brief listing of contents in no way conveys the true character and richness of this book. Its hallmark is the philosophical attitude and style of its author. There are other introductions to biology that transmit more information and are more "modern"; but there are few that

onvey, with the same intensity, the per-›nal involvement and enthusiasm of the uthor; that recapture so directly what ıe author's eyes have seen and his mind as identified as biologically significant. he many books that are nowadays writ-›n by groups of authors or at the in-igation of committees, by their nature ıck this essential ingredient.

And there are few books that make ıch delightful reading. The author has felicitous gift for telling the story in a ıvid and lucid way. Concealed behind ıe unpretentious and straightforward resentation is the skill of the experi-ıced popular writer who knows how to e elementary in the best sense of the ord without being trivial or talking ›wn to the reader. Accounts of bird ight, of parasitism and symbiosis, and deep-sea adaptations are small mas-rpieces. All technical terms are ex-lained etymologically in footnotes.

The superb illustrations contribute a reat deal to the impact of the book. hey are intimately interwoven in the xt and, together with their concise gends, become an integral part of the ory. There is an abundance of color ustrations, some in six colors, by a rst-rate illustrator. The esthetically easing arrangement of figures on the ıge adds to the enjoyment of the book. ow little attention is ordinarily paid to ch seemingly small details!

A good deal of credit for the readabil-y of the book goes to the translator, . Jane Oppenheimer, herself a distin-iished scholar and writer. One can en-rse wholeheartedly the praise of von isch in his preface: "The quality of r translation is so excellent that the ıglish version reads like a beautifully itten original work, and not like a ınslation at all." The present reviewer, ıo is familiar with the original writings the author, can testify that his pe-liar idiom is retained in an almost un-nny way.

The basic tenets that dictate the ection of the material are: the "or-nismic" view, which holds that the lividual is the basic unit in the living rld; the complementary principle of ity and diversity in organization and ıction; and the principle of adapta-n. In other words, the vantage point the book is that of the "naturalist." this, it continues a perspective and a eat tradition that should be preserved one of the foundations of biology even our times of revolutionary remolding biological thought and of increasing ecialization. This viewpoint is perhaps en now the appropriate approach to introduction to biological phenomena d concepts. Implicit in it, to be sure, limitations. The analytical and the lecular exploits of recent years, which ke present-day biology so exciting, scarcely presented in this book. This

deficiency is alleviated in part by the "Instructor's Manual" by J. F. Haynes, which accompanies the text, and by the availability of many paperbacks on all aspects of molecular biology, which can be used as supplements to the text.

One may then ask: to what kind of readers should this book be recommended? It was written originally as an introductory text for German secondary schools, and together with the above-mentioned supplements, it may serve the same purpose in this country. Beyond that, anybody between 12 and 70 who has a budding interest in biology and who is looking for a well-written and well-organized introduction to the life sciences can hardly do better than to entrust himself to Karl von Frisch as a guide. Parenthetically, many molecular biologists, and newcomers from non-biological fields, will profit from spending a few leisurely hours in this author's company.

VIKTOR HAMBURGER
Washington University

THE LIVING RACES OF MAN, by Carleton S. Coon. *Alfred A. Knopf, $10.00; 344 pp., illus.*

THIS is the second leg of *The Origin of Races*, my review of which (NATURAL HISTORY, May, 1963) holds good, by and large, for this volume. That review's summary stated: "although this book contains some glaring errors (even to inaccuracies in spelling and references) and idle speculations, there is also a mass of varied and useful data." So be it again.

This new volume may be divided into three parts. Approximately the first 200 pages deal with populations on a geographical basis. The remaining chapters (about 120 pages) outline "Racial Differences in Adaptive Characters"; "Race, Blood, and Disease"; "The Racial History of Man Since 1492"; and "The Future of the Races of Man." I would have preferred to have seen amplification of the genetic aspects of race and less of the simplified geography. The third part of the book displays 128 plates of selected national and regional types, which I would have found interesting in a popular magazine but feel are relatively useless in a scholarly publication. The legends to the photographs are occasionally highly speculative. For example, reference is made to the Bantu being "part Bushman." Some legends are reminiscent of the "romantic phase" of yesteryear's anthropology when racial divination was a frequent pastime. For example, in one plate one sees an aged, flabby-skinned woman with a scarf covering most of her head—"a Haratin . . . of . . . Morocco, showing Hottentot-like features." In another plate there is "a Rifian woman of Morocco with a broad face reminiscent of the Mesolithic inhabitants of North Africa."

Coon is fully aware that no one indi-
dual really reflects a population. If any
iotographs are to be published at all,
ey should be of the somatotype variety.
mewhat repugnant is the legend to one
ate that shows a scruffy-looking, beret-
aring individual who "bears a striking
eness to the late Pierre Teilhard de
ardin, S.J." This typifies the quasi-
rapbook nature of these plates.

One must admire the obvious ease with
ich Coon, partly on the basis of his
n extensive travels and experience,
ovides thumbnail sketches of the sa-
nt geographical features of the areas
iabited by the populations he dis-
sses. This information, only threadily
erwoven with physical characteristics,
s no broad principle lacing it to con-
ots of race formation, structure, and
bility. Similarly, his numerous excur-
ns into linguistics fail to tie in with
rphological patterns of races. Al-
ugh he often discusses the effects of
oulation isolation, migration, mixture,
quest, and physiological adaptability,
tends to view these in a recent, histori-
context, ignoring the fact that cur-
ts in history are mirrored repetitions,
eit in modified form, of prehistory.
s lack of extrapolation shines through
theories on racial origins.

Vithin this magazine's space limita-
s, it is not possible to do more than
eralize. In reading through this book,
rge number of inaccuracies and dis-
pancies were noted. One man's specu-
on is another man's misinterpretation,
Coon's assumptions often loom as
e as facts, quoted papers have been
read, and conclusions are misstated.
, this volume is a creditable vade me-
for physical anthropologists, and
d serve, with its companion volume,
e useful basis for a graduate seminar
se on race.

ut taking the broad view, as in Dry-
s *All for Love:*

"Errors, like straws, upon the
surface flow;
He who would search for pearls
must dive below."

RONALD SINGER
The University of Chicago

ARCHAEOLOGY OF NEW YORK
E, by William A. Ritchie. *Natural
ory Press, $12.50; 357 pp., illus.*

R over thirty-five years Dr. Ritchie
as excavated in New York State,
essfully piecing together the se-
ce of prehistoric cultures in New
and the northeast. In 1938, 1944,
1951 he published major syntheses
ew York prehistory, and this latest
represents his most recent and far-
ing effort in his area of study.
e volume is intended for profes-
l archeologists, students, and ama-
with broad archeological back-

ground—it is not designed to appeal to the general public. The primary purpose of the book is to describe cultural assemblages of New York State as they are currently known through archeology. Second, these assemblages are related to others, both geographically and chronologically, to furnish a sequence of culture change for the entire northeastern United States and adjacent areas, with New York State as the focus of the sequence. Thus, comparisons are made throughout to sites in Quebec, Pennsylvania, New Jersey, and the New England states. Finally, an effort is made to describe these assemblages in terms of human behavior. To accomplish this last aim, Ritchie found it useful to organize the book in terms of Components, Phases, Stages, Horizons, and other categories along the lines of Willey and Phillips' recent synthesis, rather than in the terms of the older McKern taxonomic system. Since Ritchie's earlier syntheses were set up according to the older system, recurrent adjustments of these two systems occur in the text. Although professionals will thank Ritchie for providing these equivalences, they do not add to the readability of the book.

The only quibble I wish to raise is with Dr. Ritchie's interpretations of the spread of Adena and Hopewellian burial and artistic features throughout the northeast from, roughly, 300 B.C. to A.D. 500. While, as the author proposes, migrations of people from the Ohio River Valley area may account for this spread, I wonder why he has failed to consider the possibility that it may have been caused by activities of a burial cult rather than by population movements. This interpretation is currently receiving widespread attention among northeastern archeologists. Possible cult-missionary activities must be regarded as reasonable alternatives to migration.

The format of this volume is excellent, with fine photographs and line drawings, and for a work of its size there are surprisingly few typographical errors. Ritchie's book is a tribute to his scholarly enthusiasm and painstaking research on behalf of the prehistoric peoples of New York State, and scholars will depend on it for many years to come.

RICHARD A. GOULD
The American Museum

UNDERWATER GUIDEPOSTS, by Arthur D. Hasler. *University of Wisconsin Press, $6.00; 155 pp., illus.*

THIS is a true detective story. Unlike the fictional kind, it does not come in a neat package with a nicely tied-up ending, for the mystery it describes is still in the process of being solved. How does the salmon find its way through a thousand miles or more of trackless ocean, pick out its own particular river to ascend, and

en return to the very tributary in which was hatched several years before? ıere is now virtually conclusive evi-·nce that salmon recognize each parent ream by its characteristic odor, but we ıve only vague ideas about the mecha-sm that keeps these fish from getting st in the open sea.

Dr. Hasler is one of the leading investi-ıtors of homing in fish, and much of the ›rk he describes is his own. That is un-ıubtedly why the book has the authentic ıvor of research, and it is recommended r the unvarnished but exciting view it esents of what scientific investigation is ally like. Practically everyone has ard about the great salmon mystery; is book is a fascinating account of sci-tific progress in cracking the case.

JAMES W. ATZ
The American Museum

FRICA: A NATURAL HISTORY, by Leslie own. *Random House, $20.00; 300 pp., us.*

THE casual browser in a bookstore who opens this book will gasp with won-r, as I did, at the beauty of the pic-res. The serious reader will find the xt interesting and informative. *Africa: Natural History* is part of the series he Continents We Live On," and the thor, whose clear, concise style is fa-liar to readers of African literature, s succeeded in presenting a broad pic-re of this continent, backed up by ars of firsthand experience. Leslie own has lived in Africa for twenty-five ars, and has just recently retired as ief Agriculturalist of Kenya. The cellence of the text matches his qual-ations, and he is to be further com-mented for having provided many of pictures himself. These stand up well side those of the professionals who ve provided most of the photographs.

Each chapter describes a different re-n of Africa, starting with its origin, ology, and climate, and then going on discuss the special kinds of organisms ıt live there. Mammals take up a large portion of the text. This is perhaps derstandable, since the large mam-ls are such a dramatic feature of Af-a, but I got a little bogged down ong the innumerable antelopes and nd myself longing to hear about the gs, snakes, butterflies, and mantids. e book does, after all, purport to be a ural history, not a mammal book.

The photographs are generally of the hest quality. Special commendation be given to the work of Clem Haag-', Alan Root, Emil Schulthess, and T. Miller. The printers have done an ellent job of reproduction, and the st grade of paper has been used.

So, while a first-class text and a mag-cent array of photographs have been

assembled, there has been a failure, except in a general way, to relate the two. With just a little more effort, other pictures could have been found, equally beautiful, that would have illustrated the text more meaningfully. The reader will be continually annoyed by failing to find a picture of something discussed at length in the text, and finding in its stead a picture of something with scant relevance to the chapter. For example, when discussing the Sudanese semiarid transition zone, the author states that weaverbirds are the most numerous birds in this country, and devotes a long section to them and another to ostriches, but instead of picturing weavers or ostriches, we are then shown two water birds (in a chapter on dry country), the Egyptian Goose and the Malachite Kingfisher. In the chapter on the miombo woodlands, the reader who wants to see a picture of miombo woodland will be disappointed. He can see instead a picture of a Lesser Masked Weaverbird in an acacia tree; neither bird nor tree is found in the miombo habitat.

Over a third of the photographs in the book are of mammals, mostly the large, spectacular ones, but there is not a single picture of an amphibian. This selection of photographs with an eye to beauty rather than relevance makes one suspe that the publisher may be aiming at pe ple who will glance through the book f the glorious photographs but will n bother to read the text. This would b most regrettable, and would do a grav injustice to a fine piece of writing.

Apart from this, I can find little t criticize. There are some minor errors i the text, and the maps need a little mo detail, but the level of accuracy is hig and the style is readable.

A particularly commendable and tim ly feature of the book is the emphasis conservation. As an agriculturalist, M Brown is painfully aware of the disa trous effects of the misuse of land, ar he does not hesitate to point out exar ples where political or economic e pediency have devastated the natur environment to the detriment of ever thing—including man. It is painful read of the eroded mountainsides Ethiopia, or the wasteful slaughter vast numbers of animals in the name tsetse control. As Mr. Brown says in co clusion, "Man would do well to reco nize in Africa as elsewhere that l himself is a species of animal wholly d pendent on natural conditions for h own survival. If he is to thrive, he mu pay stricter attention to the details his habitat than he does at present."

G. STUART KEI

The American Museu

MARINE ARCHAEOLOGY, edited by Jo du Plat Taylor. *Thomas Y. Crowell C $9.50; 208 pp., illus.*

THE search for ancient remains on t sea floor is an activity that knows limitation of nation or profession. T divers range from amateurs out chie for sport to dedicated professional arch ologists, and they come from half a doz different countries. This has raised o sizable difficulty: they publish th findings in all sorts of journals, fr sporting magazines to staid, scholar periodicals, and in any number of la guages. The Confédération Mondiale d Activités Subaquatiques, the dive leading organization, decided to act the matter, and turned the problem ov to Miss Taylor, librarian of the Unive sity of London's Institute of Archaeolo The result is this book.

Miss Taylor has culled up-to-da authoritative reports from vario journals on most of the major exca tions that have so far been undertak has had those in foreign languag turned into clear, readable English, a has furnished all with full bibliog phies. There is George Karo's account the first wreck to be excavated in m ern times, the lucky find off southe Greece that furnished Athens' muse with a number of magnificent pieces sculpture. There is Nino Lambogli

p-to-the-minute report on the Albenga iip, the wine-freighter that, as it now ppears, may have been carrying as uch as 70,000 gallons when it came to rief off the Italian Riviera. There is eorge Bass' succinct description of his ork off the coast of southern Turkey ı the wreck of a vessel that had aboard cargo of copper ingots and utensils robably taken on at Cyprus, known r its rich copper deposits. This amazg find dates to no less than the thirenth century B.C., predating most of e others by a full millennium. To und out the story, Miss Taylor inudes a chapter on the reconnaissance id excavation of submerged ports and irbors and similar sites, and a final iapter, from her own pen, on the genal nature of the finds and on the probm posed by changes in sea level.

Anyone interested in underwater arieology, whether scholar or amateur, ll find this book ideal for providing a iick, authoritative résumé of what has en accomplished so far. Let us hope at the C.M.A.S. will continue to bring t such useful roundups.

LIONEL CASSON
New York University

ATER, PREY, AND GAME BIRDS OF ORTH AMERICA, edited by Alexander etmore. *National Geographic Society, 1.95; 464 pp., illus.*

THIS is the second of a two-volume work covering bird species of North nerica, north of Mexico. It, too, is ishly illustrated with paintings and otographs. Despite a first printing of),000 and an assured enormous sale, price of $11.95 for each volume ms high. Nevertheless, the many table color photographs and much of artwork will be enjoyed by those erested in birds, both the amateur and professional. The outstanding pices were taken by such noted wildlife otographers as Frederick Truslow, thur Allen, Eliot Porter, and others. However, certain of the illustrations , alas, not actual shots taken in the ild," but are of posed captives. This uld have been acceptable with approate captions; the reader is entitled know which pictures were made under itrolled conditions. The many fine ntings by Walter Weber are singuly attractive, although a number of m were depicted years ago in the tional Geographic Society's two-vole work *The Book of Birds*. Most of paintings by Allan Brooks, if not all, also to be found in the earlier work. Much of the text is written by some of world's outstanding ornithologists ler the able and eminent editorship Dr. Alexander Wetmore. However, the rter articles, as well as the species ounts, are unsigned and were pre-

sumably written by Society staff personnel; these suffer by comparison. When petrels are being discussed the reader should not be faced with such anthropomorphisms as "Mother Carey's flock sounds like elves talking in the earth." A trained ornithologist would not belabor the serious reader with the gem that describes the Harlequin Duck: "It [the plumage] suggests the parti-colored costume of Harlequin, Columbine's buffoonlike lover in 18th century Italian comedy."

As with the first volume, a novel feature is the record album of bird sounds enclosed at the back of the book. Most of the vocalizations are excellently reproduced and are an asset to the work, but some of the descriptive commentary is inaccurate. By no stretch of the imagination can it be said that the Ruffed Grouse and the Blue Grouse, both woodland inhabitants, are "plump dwellers of prairie and desert," or that the Lesser Nighthawk, Pauraque, and Roadrunner, all birds of arid lands, are to be found in "cotton country."

These criticisms, however, do not detract materially from the generally fine volume—one that is certain to receive wide acclaim.

John Bull
The American Museum

Prehistoric Societies, by Grahame Clark and Stuart Piggott. *Alfred A. Knopf, $6.95; 356 pp., illus.* Ancient Europe, by Stuart Piggott. *Aldine Publishing Co., $7.50; 343 pp., illus.*

Professors Clark and Piggott, of the Universities of Cambridge and Edinburgh, are old hands at writing about prehistory. These books are learned and well written; the conclusions are tempered without being timid, imaginative without being fantastical. *Prehistoric Societies* covers the world scene from the beginning of man's story, although the Far East is rather thinly treated. *Ancient Europe* starts in the Late Paleolithic and is concerned only with Europe. There are details, hypotheses, and conclusions that prehistorians can and should take issue with, but they do not dim the excellence and usefulness of these two surveys.

A strong word of caution must be given to the unwary reader who basks in the optimistic notion that human history is a spirited pageant of advancement from savagery to civilization, from rude animality to humane dignity. Neither author's historical viewpoint is one of continual progress toward higher and higher civilization, but rather one that sees changing cultural structures with increasingly complex technologies, while man, the vehicle of history, remains about the same.

"Much of human history and prehis-

tory had no grander theme than that of the Jets and Sharks in *West Side Story*." If this be a cruel judgment, then hear Piggott's full indictment: "I have indicated my sympathy with the view that one of man's most deeply seated and most cherished needs is for aggression and dominance, violence and killing, directed against his fellowmen." The evidence leads us to believe that "what we call civilization is a most abnormal and unpredictable event." Our disappointment in man—in his inability to profit by his experiences, in his persistent folly, in his cruel inhumanity—may be the result, Piggott suggests, of our expecting too much of him, of our asking more than man's biological self has to give. But the disillusionment of the modern historian, his realization that the historical past appears to show neither a pattern of continuous improvement nor an eternal code of morality—and, hence, no hope for a better future—is cynical, but not pessimistic. Rather, these books can be seen as testimonials to the richness, variety, and optimistic striving of the human adventure over many hundreds of millenniums in spite of man's limitations. The Olympian gods, or whatever power we place in the empyrean, must be astonished that we have done as well as we have. Given our propensity for power, avarice, and destruction, as the archeological record amply documents, our accomplishments are surprising. We may never achieve humanity, but it is no small thing that we conceived it and made it into a noble goal.

These broad implications, which spring from these surveys of prehistory, are deliberately stressed here because they make archeological finds vital and exciting. Both authors deal with the minutiae of the trade—celts and arrowheads, pots and postholes, burials and house plans—but they use the evidence to reveal a coherent picture of man's capacity for culture and his experiences in achieving it.

The volumes, particularly that of Piggott, are handsomely illustrated, well documented, indexed, and attractively arranged. Either could serve as a college text, but more important, both make for absorbing reading even without the firm pressure of a classroom assignment.

BERNARD GOLDMAN
Wayne State University

Of Special Interest:

HANDBOOK OF MIDDLE AMERICAN INDIANS, edited by Robert Wauchope. *University of Texas Press.*

Vol. 1, NATURAL ENVIRONMENT AND EARLY CULTURES, edited by Robert C. West. *$15.00; 570 pp., illus.*

Vol. 2 and 3, ARCHAEOLOGY OF SOUTHERN MESOAMERICA, edited by Gordon R. Willey. *$15.00 each; 1084 pp., illus.*

NATURE AND THE CAMERA

Using polarized light

By David Linton

We are used to the idea that light acts on film much as it acts on the retinas of our eyes to produce an image. There are qualities or characteristics of light, however, to which our eyes are blind. One of these is the ability of light to be polarized: to be made to vibrate back and forth on a single plane intersecting the axis of its direction, rather than in a complex, three-dimensional, wavelike pattern.

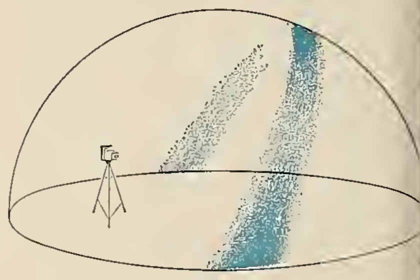
Light is polarized when reflected at certain angles from certain shiny surfaces. The most common source of polarized light is the sky. When light comes from the sun it is not polarized, but light reflected by moisture and dust in the atmosphere is polarized more or less completely, depending on what area of the sky it comes from. The maximum polarization occurs at an angle of 90 degrees from the sun. Thus if the sun is to the south, as it is around noon in the North Temperate Zone, the sky to the east and west will give light that is strongly polarized (*see drawing at right*).

Polarized light affects film just as unpolarized does, but it is useful because it can be controlled in ways that ordinary light cannot. There are special filters, or polarizers. that will pass the light vibrating in one plane and block all other light—just as color filters may pass light of one color and block others. Thus if we are photographing an object against a background of sky, a polarizer may make it possible to control the brightness of light from the sky without affecting the brightness of the subject. This gives a photographer working outdoors almost as much control as one working in a studio where the background is separately lighted and controlled by a dimmer. Furthermore. the polarity of light has no effect on its color, so polarizers can be used to darken the sky in color photographs in the same way that yellow or orange filters are used in black and white.

Finding Polarized Zone

One obstacle in this procedure is that the part of the sky that gives strongly polarized light may not be in the right place to form the background for your subject. The polarization of skylight is negligible near or opposite the sun, and increases as one turns toward the zone midway between. It is helpful to remember that the highly polarized zone will move as the sun moves, so if it is not in the right place at one hour, it may be there at another. One need not make an astronomical cal culation to figure out when this wil occur; a rough estimate is close enough

You can see the effect of a polarizin filter simply by holding it to your ey and rotating it. With cameras havin through-the-lens viewing, you can plac the polarizer over the lens and rotate i



For cameras lacking such viewing, polai izers with handles and viewing polarizei are available. The viewing polarize which is attached to the handle, align with the filter that goes over the lens, s the filtering effect you see is identical t that you will record on your film. C course, you can always just look throug the polarizer, find the best angle. an place the polarizer over the camera's ler at that angle. The photographer wi probably not want to set the polarize for maximum darkening of the sky, b cause that will give the picture an u natural and overdramatic look. Such setting is sometimes useful for technic photography, but an intermediate settin is preferable for ordinary picture takin

Side-lighted Subjects

Since the highly polarized area of th sky is at a right angle to the sun, a picture made with that part of the sk for a background will have the sunligl coming from the side. This is not o jectionable, but it may call for the u of reflectors to lighten the shadows.

With side-lighted subjects, an acc rate reading of the exposure is impo tant. A single over-all reading will oft give a wrong answer because the met is influenced by the bright highlights the edge of the subject that is towa the sun. Sometimes the background

David Linton's by-line has appeared under photographs in all the nation's leading magazines. For several years he has written for Natural History.

lso bright and may lead the meter stray. Therefore the light reading hould, if possible, be taken close to the ubject, so that the meter "sees" only the aain parts of the subject and not the ighlights or background. This may be ifficult if the subject is as large as a aountain or if it cannot be approached asily to take a reading. In such cases the ld rule of thumb is. "Side-lighted sub- ects require a one-stop increase in ex- osure." In other words, the exposure ıdicated by an over-all reading should e doubled if the subject to be photo- raphed is lighted from the side.

At least half of the light coming from ıe subject will be blocked by the polar- er, so the exposure determined from a eter reading must be corrected for ıat, too. The best way to do this is by ıking the light reading *through* the olarizer, which must be set at the angle which it will be used for the picture. ny reflected-light meter with a flat aotocell can be used in this way if the olarizer is sufficiently large enough to ıver the cell completely.

If a reading cannot be taken through e polarizer, the exposure shown by a eter should be multiplied by three. an ucated guess at the correction needed. ıese two corrections—one for the ghting and the other for the blocking light by the polarizer—are both ap- ied to the exposure given by a meter. ıerefore. if the light cannot be meas- ed close to the subject or through e polarizer, the exposure determined om a rough. over-all light reading ould be multiplied by six. For ex- ıple. the aperture shown opposite 1/60 c. should be used at 1/10 sec. If time rmits, exposures for color photo- aphs should be "bracketed" by mak- g several exposures longer and shorter an the estimated one. This procedure not so necessary in black and white, cause an error in exposure can be mpensated for in processing.

Reflecting Surfaces

EFLECTIONS other than atmospheric also polarize light. When ordinary, polarized light strikes a shiny surface, part of that light that is vibrating rallel to the surface will reflect, while rest of the light will penetrate the face reflection. The most common ample is reflection on water, although same thing occurs on ice, snow. and n on wet rocks.

Suppose we are photographing a lake. e surface, of course, is horizontal. ght vibrating in a horizontal plane l skim off the surface; it is such light t makes the lake shine. Light vibrat- in other planes will penetrate the face, making it possible for us to see the lake. By using a polarizer over camera lens we can subdue or em- asize the reflections to get the sort of picture we want. Here again, there is one angle at which the effect of light polarity is greatest. It is when the camera axis is at 35 degrees to the surface. Here, also, the exposure must either be meas- ured through the polarizer or be cor- rected for it.

The same principles apply to all shiny subjects, but with things that can be photographed under studio conditions— objects in a glass case, glazed pottery, or leaves sealed in plastic, for example— we have even more control. Since polar- izers can be obtained in any size, we can fit one over the light source in addition to the one attached to the camera. This makes it possible to control surface re- flections almost completely at any angle. Polarized light also has specialized uses in microscopy and astronomy, mineral- ogy and engineering.

The special properties of polarized light, and its many uses in photography, are another demonstration that there is more in light than meets the eye.

This list details the photographer, artist, or other source of illustrations, by page.

COVER—Georges Condominas
8-19—Georges Condominas except 13—map, AMNH after Condominas;
16-17—Courtesy of Mercure de France
20-21—SATOUR, Courtesy of Encyclopedia Americana except map, AMNH after R. C. Bigalke
22—National Parks Board
23-25—R. D. Estes, Courtesy of National Geographic Society
26—Lee Boltin
28-31—Library of Congress
32-33—Eric Hosking
34-36—Helmut Wimmer
37—AMNH
38-43—Syd Radinovsky except diagrams, AMNH after Radinovsky; 43—top right, Ross Jackson
44-51—Nancy Flowers, Nancy Palmer Photo Agency
66—AMNH after David Linton

Suggested Additional Reading

THE PRIMITIVE LIFE OF VIETNAM'S MOUNTAIN PEOPLE

Ethnic Groups of Mainland South-East Asia. F. M. Lebar *et al.* Human Relations Area Files Press, New Haven. 1964.

L'Exotique est Quotidien. G. Condominas. Plon, Paris, 1966.

THE SPRINGBOK

The Migratory Springbucks of South Africa. S. C. Cronwright-Schreiner. T. Fisher Unwin. London, 1925.

The Mammals of South Africa. A. Roberts. Trustees of the Mammals of South Africa Book Fund, Johannesburg, 1951.

Extinct and Vanishing Mammals of the Old World. F. Harper. American Committee for International Wild Life Protection, New York, 1945.

SINGULAR METAL FROM CINNABAR

Georgius Agricola: De Re Metallica. H. C. and L. H. Hoover. Dover Publications, Inc., New York, 1950.

Geology and Quicksilver Deposits of the New Almaden District, Santa Clara County, California. E. H. Bailey and D. L. Everhart. U.S. Geological Survey Professional Paper 360, 1964.

The Minerals Yearbook. Issued annually. Bureau of Mines, Dept. of the Interior.

NESTING OBSERVATION

The Sandhill Cranes. L. H. Walkinshaw. Cranbrook Institute of Science Bulletin No. 29, Bloomfield Hills, Mich., 1949.

The Herring Gull's World. N. Tinbergen. Collins, London. 1953.

The Birds of the British Isles. D. A. Bannerman. Vol. XI. Oliver & Boyd, Edinburgh, 1953-63.

MITES ON A SUBSTRATE

An Introduction to Acarology. E. W. Baker and G. W. Wharton. The Macmillan Co., New York, 1958.

Mites, or the Acari. T. E. Hughes. Athlone Press, London, 1959.

The Biology and Ecology of Granary Mites of the Pacific Northwest IV. S. Radinovsky. *Annals of the Entomological Society of America*, Vol. 58, pages 267-272, 1965.

POTTERY OF BARCELOS

Portugal, a Book of Folkways. R. Gallop. Cambridge University Press, Cambridge, 1961.

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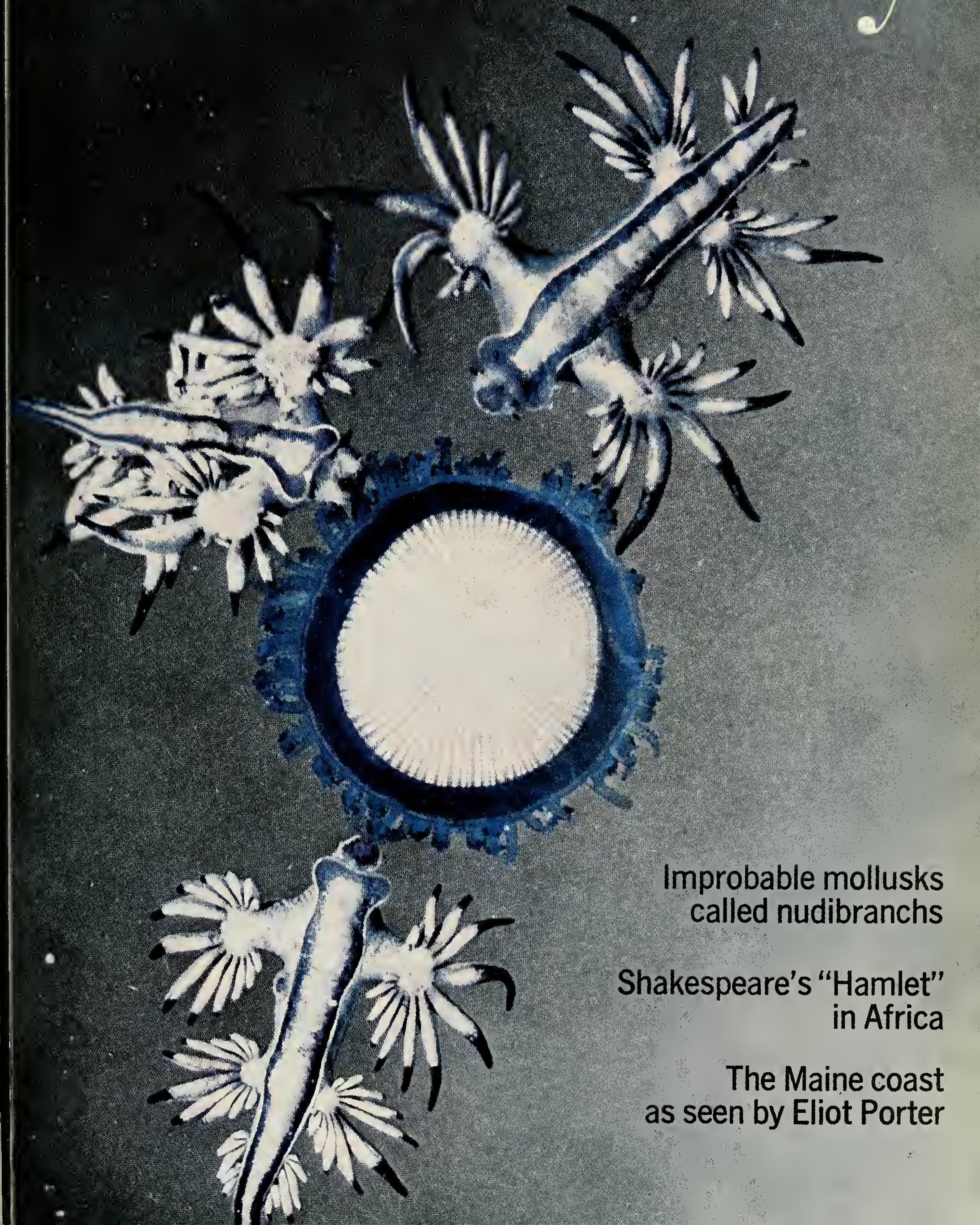
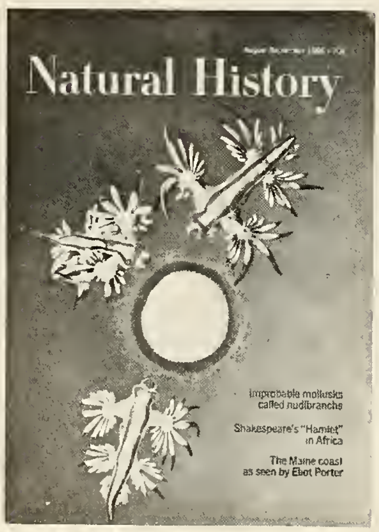


Improbable mollusks called nudibranchs

Shakespeare's "Hamlet" in Africa

The Maine coast as seen by Eliot Porter



Natural History

Incorporating Nature Magazine

THE JOURNAL OF THE AMERICAN MUSEUM OF NATURAL HISTOY

Vol. LXXV AUGUST-SEPTEMBER 1966

ARTICLES

DEPARTMENTS

COVER: Nudibranchs, which look much more like art forms than living cr tures, are members of a large group of marine and fresh-water animals tl includes the sea hares. These three tiny carnivores are feeding on the tentac of *Porpita*, a siphonophore. Their mating behavior is extraordinary, becau nudibranchs are hermaphroditic. While their penes are intertwined, eggs a extruded from the female organs of both animals. Mr. William M. Stephens to the cover picture as well as those that illustrate his article on pages 44 and

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ABOUT THE AUTHORS

The author of "The Grand Canal of China," LYN HARRINGTON, was born in Sault Ste Marie. Canada. A graduate of the University of Toronto's Library School. she has worked in libraries in Sault Ste Marie and Toronto for fifteen years. In addition, Mrs. Harrington is an author and a traveler. She and her photographer husband have jointly produced numerous children's books, as well as books and articles on their extensive travels. A recent trip to China is the basis for the Grand Canal article.

"Control Systems in Bird Reproduction" was written by D[r.] DONALD S. FARNER, former Dean of the Graduate School [of] Washington State University and now Professor of Zoophysi[ol]ogy at the University of Washington, Seattle. Dr. Farner [is] author of approximately one hundred research papers in avi[an] physiology. avian biology, entomology, and other areas of bi[ol]ogy. A member of many scientific societies. he is currently S[ec]retary-General of the International Union of Biological Scienc[es].

DR. LAURA BOHANNAN. formerly a lecturer in anthropology at the University of Chicago and at Northwestern, is now a professor at the University of Illinois. She received the B.A. degree in anthropology and classics and the M.A. degree in German from the University of Arizona. Her doctorate. awarded in 1951, was earned at Oxford. Mrs. Bohannan. whose Shakespeare article was originally written for the BBC's Third Programme. often contributes to anthropological journals and to books on Africa.

ELIOT PORTER is a graduate of the Harvard Medical School a[nd] taught biochemistry and bacteriology at Harvard from 1930 [to] 1939. He gave up medicine and turned to photography in 19[39] after a successful exhibition of his photographic work. He h[as] subsequently exhibited in many museums, including the M[u]seum of Modern Art in New York and The Art Institute [of] Chicago. His article on Maine is taken from his recent bo[ok] *Summer Island: Penobscot Country* (© 1966 by the Sierra Clu[b]).

WILLIAM M. STEPHENS, who wrote the article on nudibranchs, is Public Information Officer of the Institute of Marine Science, University of Miami. Formerly an attorney and the editor and publisher of several outdoor magazines. Mr. Stephens devotes his spare time to studying marine animals. G.P. Putnam's Sons will shortly publish his latest book. *Science Beneath the Sea: The Story of Oceanography*. A book he is now writing will explore the ecology of the Atlantic seashore.

DR. ROBERT S. SIGAFOOS and his wife, DR. MARY D. SIGAFO[OS] have long engaged in botanical research for the U.S. Geologi[cal] Survey; he since 1948, and she for four summers. Their comm[on] interest is the relationship between plants and regional wat[er] resources. Dr. Sigafoos. who received his doctorate from Ha[r]vard. lectures on plant ecology at George Washington Univ[er]sity. His wife obtained a doctorate from Ohio State and is [an] assistant professor at the University of Virginia.

DR. CARLO T. E. GAY was born in Italy and holds a doctorate in economics from the University of Naples. He retired in 1961 from the presidency of the Italian steel industry's Canadian subsidiary to devote full time to Olmec research. Dr. Gay has been interested in ancient Mexican art since 1955, particularly the art of the lithic cultures of the Río de las Balsas in the State of Guerrero. He is now working on a study of Mezcala stone sculpture that will be published by the Museum of Primitive Art.

BOOKS IN REVIEW

A foursome on nature

By Robert Cushman Murphy

THE BEST TIME OF YEAR, by Irving Petite. *Doubleday & Co., $3.95; 191 pp., illus.* THE YEAR OUTDOORS, by Eva Rodimer. *Rutgers University Press, $6.95; 294 pp., illus.* THE SENSE OF WONDER, by Rachel Carson. *Harper & Row, $5.95; 94 pp., illus.* WAPITI WILDERNESS, by Margaret and Olaus Murie. *Alfred A. Knopf, $5.95; 302 pp., illus.*

WHY are editors so prone to send out for appraisal new books that have been stripped of their dust jackets? It is no mystery to a reviewer who has many times suffered the deprivation! What, you will agree, is a better substitute for the labor of reading a long text than the publisher's admirably condensed judgment of its superior merits? And from what source other than the blurb on a jacket could be prepared a review so sure to delight both author and publisher?

With this preamble, I testify that my opinions on the following four volumes are based on perusal *inside* the covers.

The Best Time of Year, by Irving Petite, is a collection of seventeen short essays, all relating to the natural history of the mighty "Northwest." The author is both a horny-handed farmer and rancher and a man in closest sympathy with the wilderness—its waters, rock, soil, and life. He knows his plants and animals well, and he indulges in no anthropomorphizing. His accounts of turtles, coyotes, opossums, and other creatures ring true as contributions to an understanding of animal behavior.

As literature, Petite's product relies overmuch on colorful, even startling, adjectives. His opening quotation from Thoreau leads one to muse on that master's stout reliance on the verb in his unmatched journals; on his knowledge, presumably subconscious, that the sure way to grip readers is "to show 'em rather than to tell 'em."

Eva Rodimer's *The Year Outdoors* is, like Petite's book, parochial, but even more so. Its setting is old and long-populated New Jersey, instead of the state of Washington, where man still struggles harder to beat down nature than to live with her happily ever after. But what a wealth of native life remains in the small, heavily occupied terrain of one of the thirteen original colonies—to anyone properly equipped to find and recognize it! One need only read Miss Rodimer's chapter on "Forest Night" to be overwhelmed by that truth.

Her compass includes the whole expanse of the environment and seaso the entire range of life from lichens hemlocks, spiders to Luna moths, sa manders to serpents, pine siskins to ba eagles, mice and shrews to black bea What a pageant the outdoors offers to who cultivate and steadfastly make u of their five senses!

Perhaps this author's book is a l overcrowded with incident and a co trived synthesis of situation. Perhaps h creatures "think" a little too much man, himself the self-styled Lord Creation, might think under the sa circumstances. Nor does she always l the correct technical term, as when s calls the mouse's whiskers "vibrass Nevertheless, her book includes a lar proportion of the education that m citizens of New Jersey, to their loss, ha never learned.

The Sense of Wonder, by the late R chel Carson, is a publisher's post-mort buildup of notes that she had assembl toward the creation of a future book. T relatively slight text has been incorp rated with photographs of appropria charm, and the product is truly beau ful. Even though Miss Carson's pages a scarcely sufficient to add to her stature a naturalist of first rank, she sounds irresistible call for reverence for life a all the cosmos in the education of ch dren. And this gifted and lament woman knew the meaning in the words the Jesuit of tradition: Give me the fi six years of the child, and I care not w continues his education.

And now for the book by the Muri *Wapiti Wilderness*—pure gold. eve word of it, every sketch. "Mardy" a Olaus, happy mortals, never lost a jot their sense of wonder, from the crad up. They are steeped in it, and Olaus h died in it. I find it hard to turn to the ta of reviewing when flooded with the ass ciations my own wife and I have had w the Muries in the shadow of the Gra Tetons, and in the lake and alpine fa nesses of remotest New Zealand.

This is by no means a posthumo book. It was composed during ma years by the joint authors, and mold into final form by Mrs. Murie after s alone remained. Each chapter is head by the initials of the member of the p who wrote it. Yet, the work is a h monious unity, flowing without jolt dislocation.

Both Muries are no less precise th competent as naturalists. Each has sp a lifetime loving neighbors, whether h

man or infrahuman (I am tempted to write "superhuman"). In addition, Olaus had the talent as well as the soul of a true artist. Every sketch he ever drew of the world in which he dwelt is simply *right.*

Their feelings about the natural world are expressed by the words on the plaque above the fireplace of the luxurious Murie log home in Moose, Wyoming:

"The wonder of the world,
the beauty and the power,
the shapes of things,
their colours, lights, and shades;
these I saw.
Look ye also while life lasts."

Dr. Murphy, Lamont Curator Emeritus of Birds at The American Museum, is also a well-known zoologist and author.

RED MAN'S RELIGION, by Ruth M. Underhill. *The University of Chicago Press, $7.95; 301 pp., illus.*

IN the lucid, easy style we have come to expect from her, Ruth M. Underhill presents a "popular" volume on an important aspect of American Indian life. Popular is in quotes because only the absence of citations, footnotes, detailed descriptions of apparatus and processes, and exhaustive analysis separates this graceful work from the scientific category. Her frequent descriptions of personal experiences in the field add freshness, excitement, and reality to the text.

Dr. Underhill holds that basic to the spiritual conceptions of all American Indian groups is a body of beliefs remarkably similar to the substratum of religious notions common to primitive cultures throughout the world. Her thought is that the ancestors of the Indians who migrated to the Americas from Asia during the late Ice Age, perhaps twenty thousand years ago, brought with them the kit bag of religious notions possessed by all early human groups.

The work is developed by considering the variations played on these notions by many different Indian groups (and, indeed, still played, for the author brings her study into modern Indian life and the North American Church) under ecological and economic pressures or the strong personalities of occasional, effective religious innovators.

There is no one Indian religion, of course, even as there is no one religion among other groups of peoples, and of necessity, Dr. Underhill selects specific tribes to illustrate inevitable generalities. The book is concerned primarily with Indians north of Mexico, but even so, her field of choice is very wide, and she has had to consider religious influences from Latin America, as they impinged on North American tribes. Her choice of individual tribes is good.

She ranges from the Tlingit of the Northwest Coast to the Cheyenne of the Plains. the Iroquois of the northeastern, and the Creeks of the southeastern. Woodlands. the Pueblos of the Southwest. and the Naskapi of Canada. She speaks of ceremonialism in its many forms—hunting rituals, war ceremonies, vision experiences. and devices for avoiding harm from the dead. Groups are considered in their cultural setting as hunters and gatherers, hunters and farmers. and Plains nomads.

The illustrations are good and apt. The bibliography is excellent. In short, buy this one.

JAMES L. SWAUGER
Carnegie Museum

THE ANCIENT PAST OF MEXICO. by Alma M. Reed. *Crown Publishers, Inc., $7.50; 388 pp., illus.*

As a record of the author's lifelong association with Mexico and its pre-Columbian archeology. Alma Reed's new book, *The Ancient Past of Mexico*, should not be overlooked. Her aim is "to link descriptions of recent archeological discoveries with historical data to give a broad survey of what is now known of pre-Conquest Middle America."

She has long been known as an enthusiastic admirer of Mexico, and in writing about it her training as a newspaperwoman is always conspicuously evident.

When she discusses archeology, she attempts to restate the arguments of the professionals without passing judgment on them and without seeking to reconcile the striking inconsistencies among different experts' conclusions. Her method is to report in haste. rather than to resolve. The tone is breathless and newsy —telling wonderful facts that strain belief but never supplying the reader with proofs or detailed descriptions.

Errors of fact and involuntary misrepresentations often occur. Fantastic notions receive the same respect as proved and tested theories. The pace is as rapid as air travel, leaping about from topics to places to people to anecdotes.

The merit of the book lies in the record of her personal experiences. When she describes a place or a site. it is in relation to the people she has known who worked there. Ideas and theories are offered as those of specific persons. Like the text, the illustrations are of uneven quality and interest, but some are indispensable and unique.

Although it falls short in perspective and balance, the text is rich in colorful detail, and mentions many lesser-publicized sites. When the chaff of "journalese" is separated from the wheat of experience, a good deal of nutriment remains.

GEORGE KUBLER
Yale University

DISASTER BY DEFAULT. by Frank G. ham. Jr. *M. Evans & Co., $4.95; 256*

THIS book is an interesting additio the literature of what might be cal "ecopathology," since it reports. o and over again, the confusion in minds of people—many in important influential positions—between mo and the health and general well-being the environment, including human ings. In a country and period unpre dented in the history of the world for "high" living standard (which might questioned on philosophic or semar grounds). with the highest national capita income ever known. with incr ible amounts of money being spent gadgets and baubles. and with corpo tions breaking all records with the m nitude of their profits. we have here record of citizens. politicians, and b nessmen whining that they cannot ford" to keep increasingly unbelieva amounts and combinations of ordure of their drinking and bathing wate

Based largely on House Committ Public Health Service, and Health. E cation and Welfare hearings and repo *Disaster by Default* shows the noiso state of our major river basins. par from human wastes and partly from dustrial wastes. for the disposal of wh neither the body politic nor the busin community has taken the responsibili

Indeed, the author cites several instances of business blackmail: make us dispose of our own wastes and we'll move out of the town or state. The ineffectuality of local and state authorities forces the intervention of national government to which so many businessmen object. (The book gives a good background for understanding the shocking Spilhaus report.)

The solutions Mr. Graham suggests are not very encouraging. One experiment he seems to view with favor is that the wastes be "oxidized to carbon dioxide and water" and driven out through chimneys, disregarding the already significant increase in carbon dioxide that was recently discussed at a conference of the Conservation Foundation.

Nowhere does he advocate, as an obvious part of the solution, stabilization—or even reduction—of population. In a finite world a limit must be reached sometime; the sooner the better. The recent Hudson River Commission Report projects a population of 30 million humans for New York State within 34 years, most of it in the Hudson Valley. Does anyone think this area can be saved from slum deterioration with such densities and such quantities of waste to be got rid of? Even though the money piles up and up?

Mr. Graham says, of New York City: "One recent sewage program cost the city $87 million; it is estimated that $450 million will be needed to complete the construction of interceptor sewers and treatment plants before the city's wastes will approach modern . . . standards."

The book is deficient in failing to identify the sources of its citations and quotations and, like more and more books currently published, has a miserable index.

WILLIAM VOGT
The Conservation Foundation

SOUTHERN AFRICA: DURING THE IRON AGE, by Brian Fagan. *Frederick A. Praeger, $7.50; 222 pp., illus.*

THIS is a welcome addition to the "Ancient Peoples and Places" series that has done so much to present, in a straightforward fashion, the findings of archeologists and ethnohistorians. Brian Fagan's contribution to the series provides a conservative outline of the materials at hand, as well as bibliographic guides to further study. For the serious student, this volume is a useful beginning; for the lay reader, the numerous maps, line drawings, and photographs may be enough.

The book has thirteen chapters, all of them short. They cover geography; climate; ethnic distributions; Stone Age cultures; early subsistence farmers; the spread of iron technology; Zimbabwe, Monomotapa, and Inyanga cultures; and regional summaries of cultural developments in Zambia, Rhodesia, and South Africa. The final chapter is a brief excur-

sion into events of the nineteenth century.

Most of these chapters are only ten or so pages long. Given such brevity and the high informational content of the text, the reading is not always easy. Let the attention wander, even for a phrase, and a one and only reference to the important Neolithic site of Nok may well be missed. An index, which otherwise appears to be fairly complete, has no entry for Nok and none for the Neolithic, although there is a useful map showing the distribution of these early cultures, and several pages are devoted to their review.

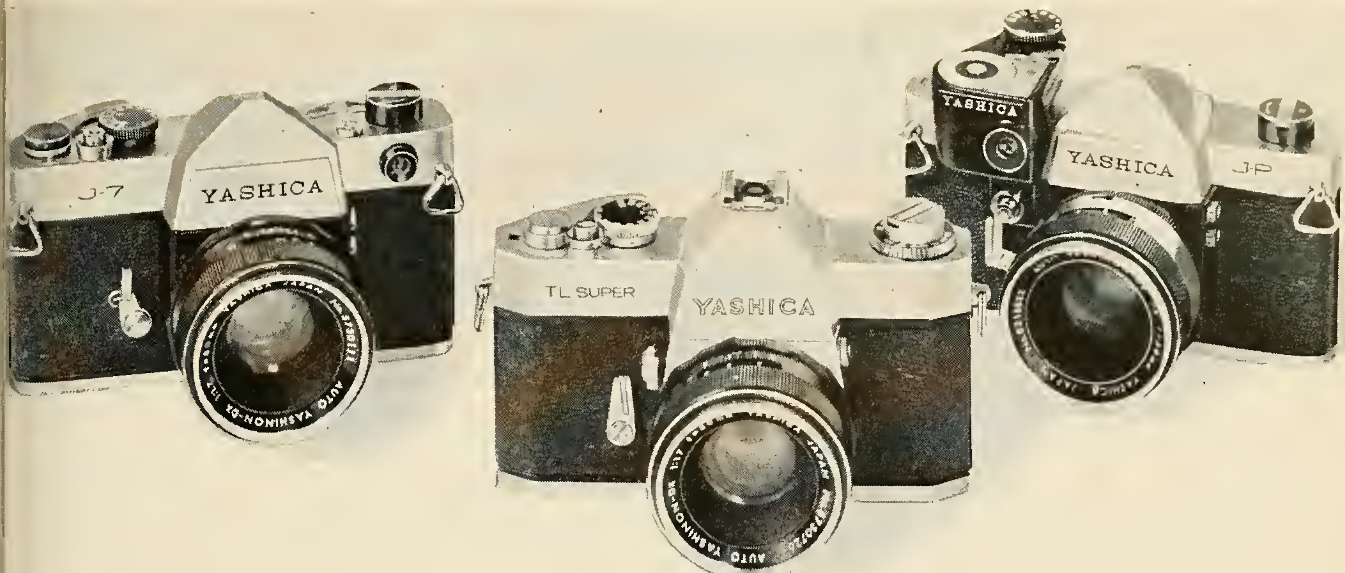
Marginal headings and references are a great convenience to the reader in relating the text to the numerous illustrations. Most of the line drawings indicate size by means of reduction ratios, such as 1:4, 1:9, etc. A reader lacking a pair of proportional dividers or a ruler, and the time and willingness to do the necessary arithmetic, may never get a very clear idea of the actual sizes of the many different artifacts—from finger rings to battle axes—that are illustrated. Distribution maps and plans of different sites are all clearly drawn and keyed both to the text and relevant photographs. The plates themselves are well reproduced, and many of them are of striking quality.

In a Preface, Fagan informs the reader that the text of the book was completed prior to a recent revision of much of the terminology for the different periods and cultures of African prehistory. A lack of uniformity has long plagued the technical literature on African archeology and prehistory, and it is particularly unfortunate that the text of the volume under review does not include a table or chart showing the various cultural sequences and the names they are given by different authors. This would be of great help both to the general reader and the student. If further editions of *Southern Africa* are planned (and, in view of the rate at which discoveries are being made in the archeology of Africa, a new edition soon will be mandatory), such a chart should have priority over all other revisions. In the meantime, Fagan's present volume must stand as one of the best available introductions to the prehistory of Central and South Africa.

FRANCIS P. CONANT
Hunter College

THE ART OF THE ROMANS, by J. M. C. Toynbee. *Frederick A. Praeger, $7.50; 271 pp., illus.*

BOOKS on Roman art have appeared with moderate frequency in recent years, part of the general outpouring of lavishly illustrated art publications with abbreviated texts. Because Roman art has been less well served than other periods, the publication of books in this field has rendered valuable assistance to the student or layman interested in this



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aspect of Classical civilization. In the absence of comprehensive, scholarly studies of Roman art, the authors of these books have been obliged to present, as scholarly contributions to a discerning public, their own syntheses within the limited format of popular editions. This is precisely the achievement of Dr. Jocelyn Toynbee, formerly Professor of Classical Archaeology at Cambridge. Professor Toynbee has written a clear, didactic essay on the principal developments in Roman art from the sixth century B.C. to the fourth century A.D., and it is a distinguished addition to the useful, inexpensive series "Ancient Peoples and Places."

The Art of the Romans is devoted to an illuminating exposition of Roman painting, sculpture, and mosaic. The omission of architecture, that most Roman of all media, limits the comprehensiveness of her book. However, the dimensions of her subject are still vast. They are complicated by the greatest variation of form and meaning in works of art created over an area that extended from the Atlantic Ocean to Mesopotamia during almost one thousand years of continuous activity.

The author has treated these diverse manifestations of Roman art within the scheme of a categorical framework that emphasizes the metropolitan (Rome), regional (the provinces), and cosmopolitan (the Empire) character of its monuments. The structure of her presentation depends on a thematic analysis, loosely apportioned among different media and various motifs, such as portraiture. Therefore, the book as a whole is not chronologically arranged, although the historical evaluation of each theme is carefully, if briefly, delineated.

Despite the exclusion of architecture, the limited treatment of iconographical problems, and the thematic selectivity f the chapters, the reader's appreciati of Roman art and of its special qualit will be stimulated by the perceptive d cussion of portrait sculpture, historid reliefs, wall and ceiling paintings, a l mosaics. Less successful, but still inf mative, are the rapid accounts of deco tive sculpture and of painting in t minor arts, which lack the penetrati commentary that enlivens the other cha ters. This excellent and provocative troduction to the plastic and pictor arts of the Romans concludes with well-chosen bibliography and ninety-o representative illustrations in black a white, accompanied by useful notes.

RICHARD BRILLIA
University of Pennsylvan

LIFE AROUND US, by Fritz-Martin Eng *Thomas Y. Crowell Co., $6.95; 206 p, illus.*

ONE might well approach cautious a book with a text of only 196 pag that bears the all-inclusive title of *Li Around Us*, and has the even broad subtitle *The Strange Planet Earth an the Stranger Creatures That Live On*

The book is loosely organized in eight major chapters and a one and quarter page conclusion, which ob ously means that information must drastically abbreviated. As one examp of brevity, organic evolution is trac from the earliest "undifferentiat lumps of protoplasm" up to the prese in less than two pages. As another e ample, the statement that successf locomotion on loosely packed substrat requires broad feet is followed by i numerable, one-paragraph examples animal forms—ranging from skinks camels—whose anatomical paraphern lia are suited to life under this conc tion. Very seldom are one or two exce tionally diagnostic cases cited in det to explain some form of adaptation.

The author covers such a broad spe trum of nature that the reader is bou to acquire a multitude of new and dive sified scraps of knowledge. For exampl I learned that a snail can climb over razor blade without nicking its fo fairy armadillos use their horny tails antiskid devices, it takes 24 cc. of wat to produce 25 grains of wheat, coc roaches will eat shoe polish, one mu trim the toenails of mountain sheep li ing in woodlands, and the dung beet can smell its food five yards away.

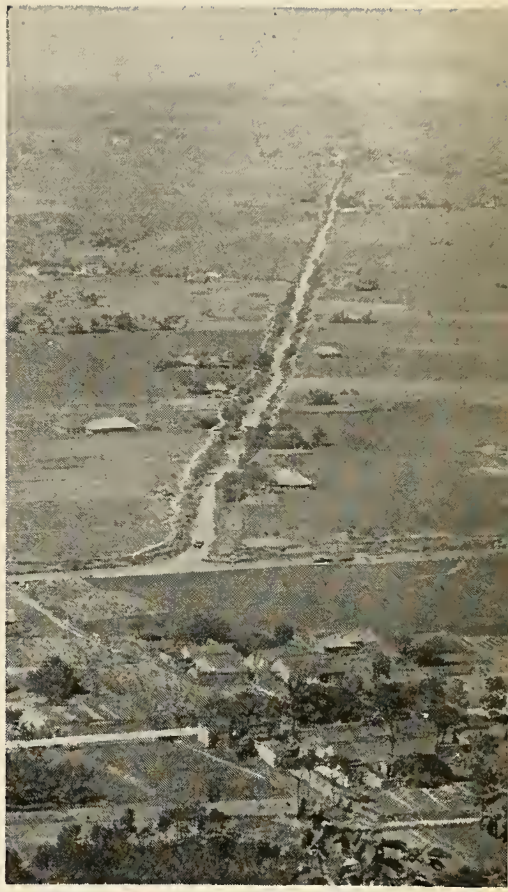
In summary, the book is a potpourri geological, meteorological, and ecolog cal facts. The level of presentatic would suggest that the book was writte for the amateur naturalist. However, tl extensive ecological terminology wi make reading difficult for this group.

JOHN D. PALME
New York Universi

The Grand Canal of China

Longest of all man-made waterways has been used for nearly 2,500 years

by LYN HARRINGTON



Grand Canal is seen from the Leaning Pagoda, near Soochow; one of many side canals runs back to mountains.

The Grand Canal of China has never received as much attention n history and travel books as has the reat Wall, but the long inland aterway is infinitely more interestng and considerably more useful. /hile the Great Wall kept nomadic ibes at bay for centuries, the Grand anal has been in active use for alost 2,500 years. It was started in 06 B.C. when King Ho Lu of the ingdom of Wu had the first section ug from the Yangtze River south to ai Lake, just west of Shanghai (*see ap, page 18*). His son, Fu Chai, exnding his rule northward, built the cond section from the Yangtze orth to the Hwai River. A thousand ears and a dozen dynasties later, the anal reached the "grand" stage nder the leadership of Emperor ang Ti of the Sui dynasty. Millions peasants and artisans toiled for x years (from A.D. 605 to 611) to tend the canal south to Hangchow nd north to the Yellow River, from hich navigation could either proed east to the river mouth or west the then capital of Loyang in onan Province. Then, after Kublai han established his capital at Peng in 1263, the canal was carried rther north and its southern route onsiderably shortened.

The Grand Canal runs for 1,100 iles, and is the longest man-made aterway ever constructed. It is approximately ten times as long as the Suez Canal and twenty times as long as the Panama Canal. It has been undergoing a thorough rehabilitation since 1958, and a ten-mile section from Peking to Tungchow, silted for many years, is at present being replaced by a new, larger channel. Since China's rivers slope from western plateaus to eastern lowlands, the canal provides the country's only interior means of north–south navigation. Linking five major river systems and a network of small canals, it is not simply a trench cut at right angles to the rivers; it follows the course of some of the lesser streams. Its depth varies from a six-foot norm, depending on the season, and its flow is checked by floodgates and barrages.

The section of the canal now under reconstruction, called Pei Yun Ho ("north transport river"), stretches to Tungchow, site of a 13-story, solid brick pagoda. There it turns abruptly south, and outside Tientsin crosses the Hai River—a combination of three rivers, which until recently often flooded the city. The canal then becomes Nan ("south") Yun, and angles through the populous provinces of Hopeh and Shantung, where it crosses the Yellow River. This intersection, unmodernized as yet, is a difficult one because the river runs between high dikes, and its bed is higher than the land on either side. Here cargoes are either transshipped, or boats are hauled up on a ramp on one side of the dike and skidded down on the other.

When it enters Kiangsu Province, the canal cuts through rock in coal-mining country. At Suchow it angles east and then south to skirt Hungtze Lake. This is the outlet for the Hwai River system, which drains 124,000 square miles. Once an easy-flowing stream, the Hwai caused a lethal flood in 1855 when its outlet was silted up by one of the Yellow River's freakish deviations.

Farther south the canal hugs the eastern shore of Kaoyu Lake, and near Yangchow crosses the mighty Yangtze River. The current here is powerful even at low-water periods. At high water, the Yangtze pushes into the canal in both north and south directions, and is contained by the canal dikes, which act as a safeguard against flooding. Below the Yangtze, the canal crosses beneath, then parallels, the Nanking-Shanghai railway. It winds around Wusih, forms a Venice-like moat for the walls of Soochow, connects with lovely Tai Lake, and with a final westward bend

loaded with rice straw is in the channel of canal. To obtain more , oars cross in front of rower.

Map shows route of the Grand Canal. It extends from Peking, in the north, 1,100 miles to Chekiang Province.

through Chekiang Province reaches Chientang River below Hangchow's Lu Ho Ta (Six Harmonies) Pagoda.

Most navigation on the Grand Canal and its branches is concerned with moving grain, vegetables, diesel oil, coal, iron ore, package freight of all kinds, and livestock. Women operate donkey engines to load the boats, and stevedores, both male and female, haul loaded carts over the cobbled quays. Other women sell tickets for the passenger motorboats that move up and down the innumerable waterways. These ferries are not luxury craft, but do permit a glimpse of life along the water artery.

Fortunately, because of good management and the centuries-old custom of collecting human waste and returning it to the land, the Grand Canal is not an open sewer. Some boats on the canal are laden with this waste, carrying it from town to commune, where it will remain in a pit for seven weeks before being carried to the fields. Others are engaged in the parallel activity of scooping muck from the canal bed. The rich sludge contains snails and freshwater clams, some edible, and the shells contribute lime to the soil. Such top-dressing has maintained land fertility for thousands of years.

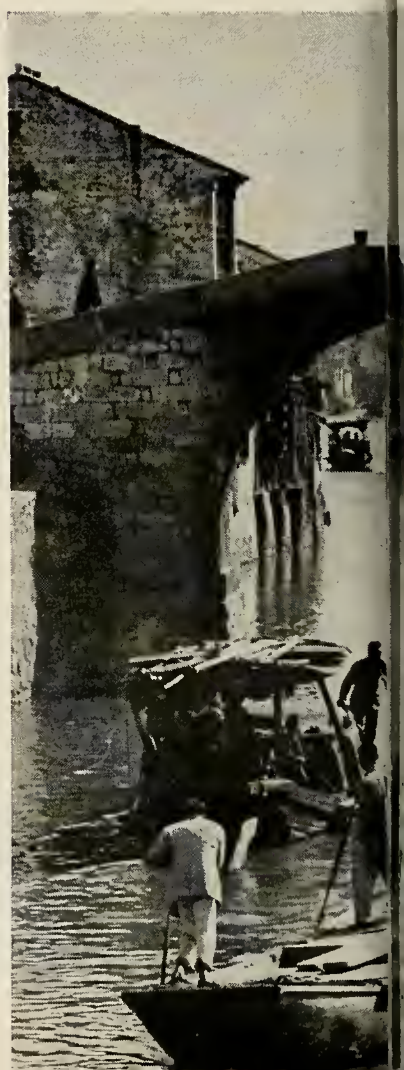
Most of the blunt-ended, flat-bottomed vessels on the Grand Canal are wooden, including the sampans from which the fisherfolk agitate the water with bamboo poles, then release cormorants to retrieve the fish. Other boats, made of cement, are designed on the traditional pattern, but have air spaces fore and aft. Although heavier and somewhat sluggish, the concrete boats are more durable and cheaper than those of timber.

White-sailed junks transport goods and house fisherfolk. These people may form a "production brigade" in an agricultural commune, or may have their own commune. One commune on Tai Lake has five brigades and 700 vessels. Thus organized, the fishermen co-operate rather than compete, and their catch is hurried to market in an orderly way. With joint accumulated funds they have constructed safe harbors for their boats, and are now building homes and schools onshore.

Running through four heavily populated provinces, the Grand Canal has played a historic role in political unification as well as in economic development. In feudal days whoever controlled the canal controlled China. Its recent reconstruction has also benefited the national economy, for heavy goods are shipped more cheaply by water than by rail. Massive shipments of food and grain move from rural areas alongside industrial raw materials and the finished products of China's new factories. In coal transport alone the restored canal has already led to spectacular monetary savings. Diesel motorboats tow strings of barges that carry 200 to 500 tons of cargo, and smaller craft are propelled by rowers using a huge, bent sweep oar that also serves as a rudder.

Canal cuts are too narrow to allow tacking, although a sail may catch a favorable breeze as the canal bends. At times the mast will be taken down to permit a boat to pass under some low bridge. Old bridges erected during the Ming dynasty (1368-1644), particularly those in the Soochow-Wusih section, are as pretty as they are useful.

Reaching a peak of usefulness in the centuries following Kublai Khan, the Grand Canal fell on hard times in the last century. The Ching dynasty inaugurated coastal shipping in the 1870's, and Europeans built



Tollhouse is on the Ming Bridge over Grand Canal in Soochow. Keepers used to collect tolls by lowering long pole.

gh sails, stiffened with wooden tens, are stained and patched. They k up winds from the China plains.

Concrete boat, below, is seen in an arm of the Grand Canal that once was part of moat of the old city of Wusih.

railways at the turn of the century. Also, funds for the canal's upkeep were diverted for imperial extravagances and suppressing rebellions.

The confusion of the revolutionary years also militated against canal maintenance. Understandably, local war lords did not take a long-range view of the country's needs. Anyone using the canal was at the mercy of war lords or bandits to whom tribute had to be paid. The keeper of the ferry cable, too, might use his cable as a barrier to passing boats until he collected his squeeze. During the war with Japan (1937-45) and the civil war (1947-49), large repairs were planned, but few were carried out.

But the canal's worst enemy was the uncontrolled flooding that tore away embankments and towpaths, breached neglected dikes and floodgates, cut new channels, and silted the old ones. Peasants whose land was inundated often starved, or if they were lucky they raised lotus root and water nuts in the old overflow. Two floods and two droughts every three years was the average, with a serious flood or drought every decade.

Only a stable government could put the canal back into service, for by 1949 the lower mid-section alone was in operation. And it was useless working on the canal until the rivers that menaced its existence were harnessed. In fact, control of the rivers had a much wider purpose than restoration of the Grand Canal. Reservoirs would provide for city needs and farm irrigation and clean up stinking swamps as well. They could be stocked with fish to add protein to the diet, and many of the dams could produce hydroelectric power.

All of these improvements have now been made. The 1958 spurt in Chinese economy and industry overburdened the railways and made it feasible to restore the canal. Work first began in northern Kiangsu, a region rich in grain, fish, salt, and coal, which required cheaper transportation to the industrial cities of the Yangtze—Wuhan, Nanking, and Shanghai. Rural communes contributed men and women—armed with mattocks and shoulder-pole baskets—to the project, and thousands of technicians and water-conservancy experts joined in. Within three years 160 million cubic meters of earth and rock had been excavated in one section, and in another, where river curves were designed to retard the current, the bends were straightened or widened. A new 60-mile section near Suchow was cut through rock to bring it close to coal mines for efficient loading.

Millions of trees have been planted to check erosion, and thousands of small check dams on creeks combine with larger river dams and great reservoir walls to hold back the waters of the Yellow, Hai, Hwai, Yangtze, and Chientang rivers. Yellow River dikes have been raised, widened, and faced with cut rock to prevent further breaches, and lateral canals have been dug to carry off excess floodwater from the canal to the sea. Old sluice gates have been replaced with modern, electrically operated locks, so that traffic moves swiftly and

Sampans and junks, along with fl
blunt-nosed modern boats, make
much of the water traffic on the can

Although electric power is available, many peasants still employ primitive treadmills known as "dragon-back."

A farm on which ducks and geese are raised borders the banks of the Grand Canal in the central Hangchow area.

smoothly. The old gates, with their sudden outflow of water, sometimes wrecked boats; people called them "the gates of Hell." The shallows have been dredged and the dikes improved. In time, the barges may carry 2,000-ton loads between the new navigation markers.

Along with technical changes, life beside and on the Grand Canal of China has quickened and improved. Yet some old habits linger. Peasants still use the "dragon-back" treadmill pump for small fields, although electric pumps provide water for the large paddies. Graves still occupy too much land, although the peasants are switching to cremation.

However, these customs are vanishing before the advance of science, and an increased interchange between city and country dwellers is bringing about other changes. But while no one can predict the course of politics, it appears that no radical change will come to the Grand Canal itself. It will probably continue to be useful for many more millenniums.

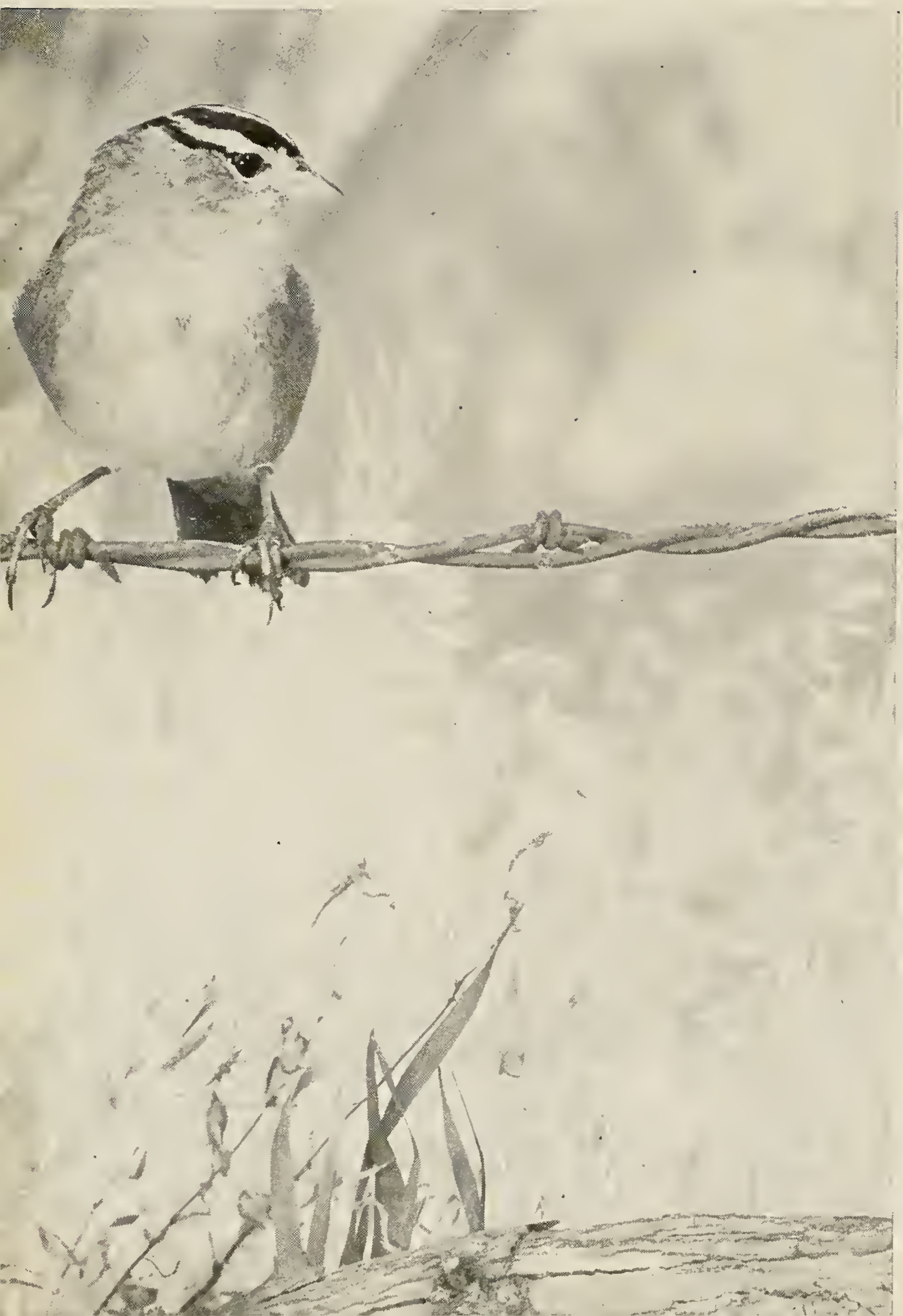
by DONALD S. FARNER

Control Systems i

HYPOTHALAMUS REGULAT

In Senegal, a bird called the Red-billed Dioch, *Quelea quelea*, begins breeding after the rainy season, in June or July, when insects are plentiful and a luxurious growth of grass provides seeds and nesting material. Northward, in the Arctic and subarctic, the White-crowned Sparrow, *Zonotrichia leucophrys gambelii*, also performs its reproductive activities early in the summer. But this sparrow, like many other summer residents of the polar region, must make an additional adjustment. Its reproductive activity must be concluded sufficiently early in the summer so that a long enough period of good weather and adequate food conditions remains for molting, preparation for migration, and departure south.

In most avian species, the energy-demanding processes of reproduction take place in a season of abundant food, water, and nesting material. Generally, these processes occur with an annual periodicity, even in regions with seasons that are not sharply defined. The advantage to the species of such timing is obvious: reproduction takes place when the probability for survival of the young is greatest.



But the precise timing mechanism that regulates reproductive activity in the individual bird is less obvious and more complex. In order to insure that reproduction will occur at the best time, preparation must begin substantially in advance of the reproductive period because of a physiological lag between the onset of the breeding cycle and the time at which a bird is actually reproducing. In many species the individual bird must somehow "predict" the arrival of the time at which reproduction should occur, so that the development of the reproductive system can begin appropriately early.

I shall make a brief appraisal here of some of the mechanisms that control the seasonal development and function of the reproductive systems of birds. It must be emphasized that the fundamental control system—that is, the system that provides the general timing of reproductive development—establishes only the approximate time at which reproductive activity begins. The precise starting date involves effects of behavioral interactions and local environmental conditions, a subject beyond the scope of this article.

Considering the variety of control systems that have evolved in birds, our knowledge is fragmentary. Nevertheless, from the increasing numbers of investigations, which began with the classical experiments of William Rowan forty years ago and those of T. H. Bissonnette shortly afterward, interesting and useful concepts are emerging. A basic but controversial question is whether the timing mechanisms depend on environmental information or on intrinsic periodic functions ("internal rhythms"). In every species evolution has probably produced a control scheme involving both, since it

Bird Reproduction

AVIAN BREEDING ACTIVITY

is unlikely that any species could rely exclusively on either external information or on internal timers.

From the research of J. Benoit and I. Assenmacher in France, as well as from subsequent studies by others, it is clear that the central organ in the control of reproduction in birds is the hypothalamus, an important control center in the ventral part of the diencephalon—the posterior part of the forebrain. Basically, as shown in the upper diagram on page 25, the hypothalamus exercises its control through nerve cells that discharge neurohormones into the blood of a special vascular system leading to the sinuses of the adjacent anterior pituitary gland. The neurohormones control the rate at which the anterior pituitary releases gonadotropic hormones into the blood stream. These hormones stimulate the gonads and control their production of germ cells and sex hormones.

Although much is to be learned concerning the details of this system, it is common to all birds. What differs among species is the battery of information, both external and internal, that the hypothalamus uses. The lower diagram on page 25, which is generalized and fits no single species, indicates the available mechanisms from which the elements of a control scheme may have been selected and modified in the course of its evolution. As a component of both the nervous and endocrine systems, the hypothalamus occupies a strategic position for receiving and processing information from external and internal receptors (by means of nerve impulses) and from hormones and other blood constituents.

Many kinds of environmental information are involved in the control of avian reproduction. In the photoperiodic species, in which day length controls the reproductive processes, temperature may also be a source of information, although its variability from year to year limits its reliability. It has an important modifying function, however; reproductive activity is appropriately retarded if there is a late cold season.

Many other external sources may be important in fixing the final schedule of reproductive activity. Male Lincoln's Sparrows, *Melospiza lincolnii*, for instance, do not establish definitive territories—an important phase in the annual reproductive process—until the snow disappears, at least partially, from the mountain meadows. The female House Sparrow, *Passer domesticus*, first uses increased day length as a stimulus to begin reproductive development, but completion requires at least two other environmental stimuli: the presence of a sexually active male and the availability of a nesting site and nesting material.

Sources of internal information are equally important. Among these are "circadian" periodicities—fundamental, internal periodicities of approximately 24 hours. Circadian periodicities can be identified by

Seen here are White-crowned Sparrows. This species is highly photoperiodic.

placing animals in constant conditions of day and night and observing the rhythm of, say, their motor activity or feeding behavior. Under natural conditions, the 24-hour day–night periodicity of the environment enforces a similar periodicity on the animal's physiological and behavioral functions. Studies of photoperiodic control mechanisms in plants and insects have indicated that organisms "measure" day length by reference to a "biological clock" (NATURAL HISTORY, March, 1966). Such a clock is now known to be involved in the photoperiodic control of the reproductive cycles of birds.

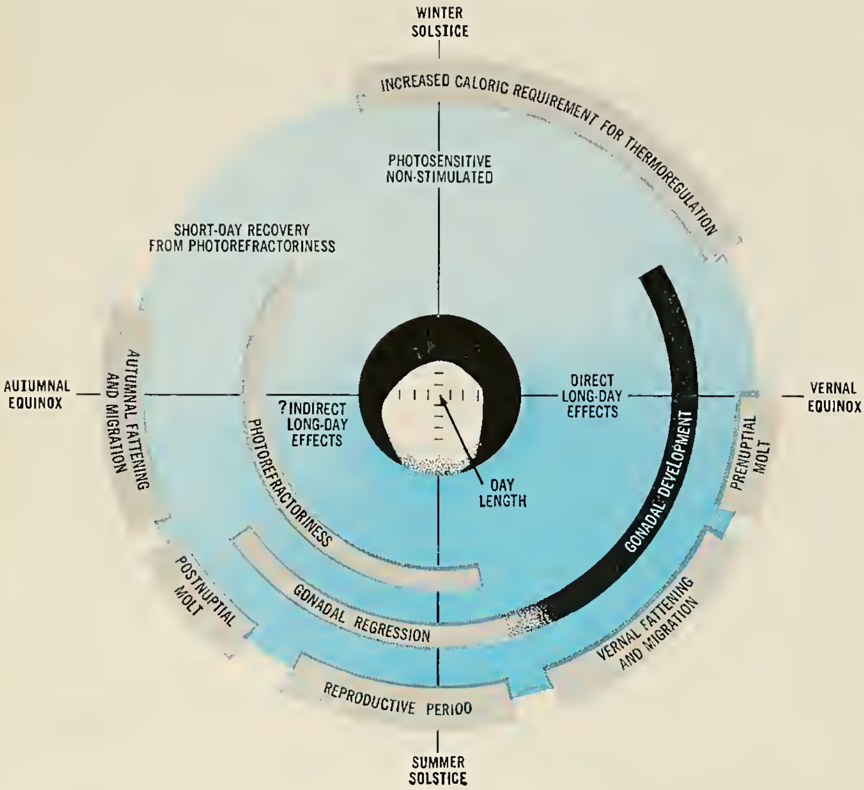
There is also evidence in some species of a "circennial" (approximately annual) periodicity. This is a rhythm that is somehow entrained by an environmental cycle of strict annual periodicity—day length, perhaps, or climatic variations. The strongest evidence for this comes from the investigations of D. L. Serventy and A. J. Marshall in Australia on the transequatorial migrant, the Short-tailed Shearwater, *Puffinus tenuirostris* (sometimes called Slender-billed Shearwater in America). The breeding cycle of this species is remarkably precise, despite its long migratory path, shown on the map on page 26. It arrives at its breeding

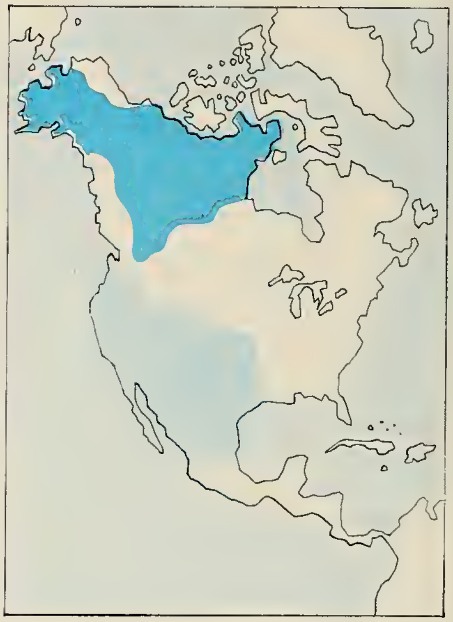
Zebra Finch breeds in drier parts of Australia, and reproductive activity is timed to irregular rainy seasons. Adult and three young are shown here.

area during the same eleven-day period every year. Day length in this case, however, does not appear to be the determining factor.

For most species, the sex hormones, and possibly also the gonadotropic hormones, are another source of internal information for the hypothalamus. While the hypothalamus causes the pituitary to increase the output of gonadotropins, which in turn cause increased output of sex hormones, a sufficient amount of these hormones in the blood can inhibit this action of the hypothalamus. In photoperiodic species, the "negative feedback" thus set in motion may be involved in the development of photorefractoriness—a period of reproductive quiescence. This complex effect continues even after the gonads have stopped releasing inhibitory hormones, and usually extends to late fall or early winter. During this time gonadal development cannot be induced by experimentally increasing day length.

My colleagues and I have studied a migratory race of the White-crowned Sparrow for more than a decade. The breeding area of this race (*see map, below*) extends from northern Wash-





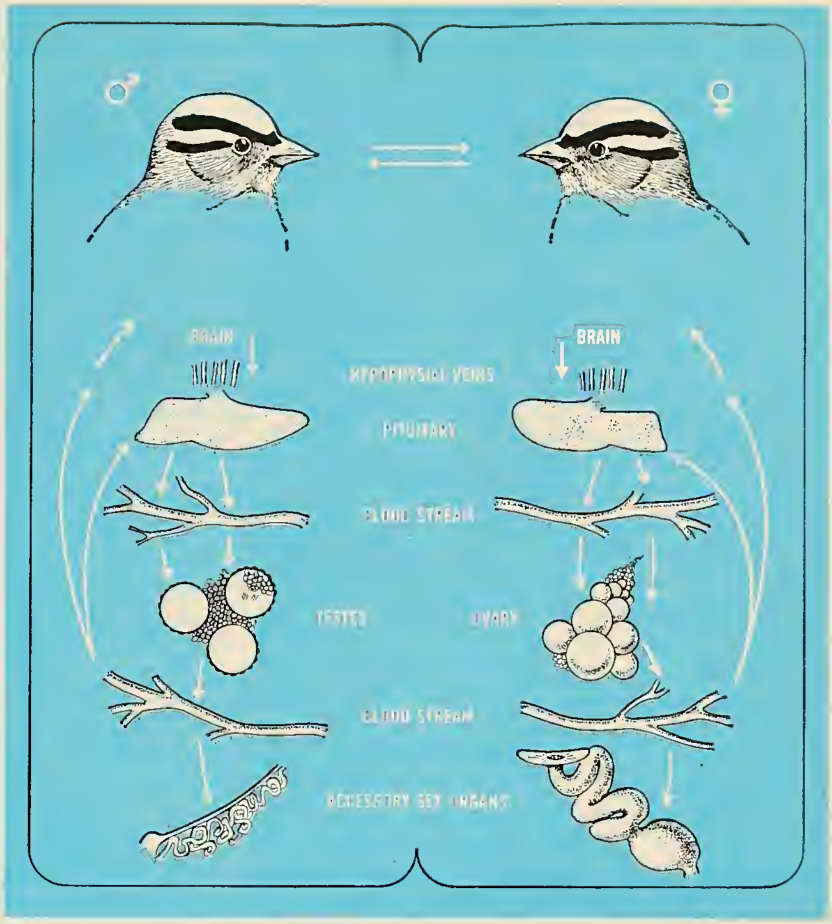
The White-crowned Sparrow winters in the western U.S. and breeds in Alaska and portions of northwestern Canada. Illustrated at left is the control that day length exerts on the events of the annual cycle of this migratory bird species.

ngton to well beyond the Arctic Circle. Its principal wintering range is in California and Baja California, although wintering populations are also found farther eastward and northward.

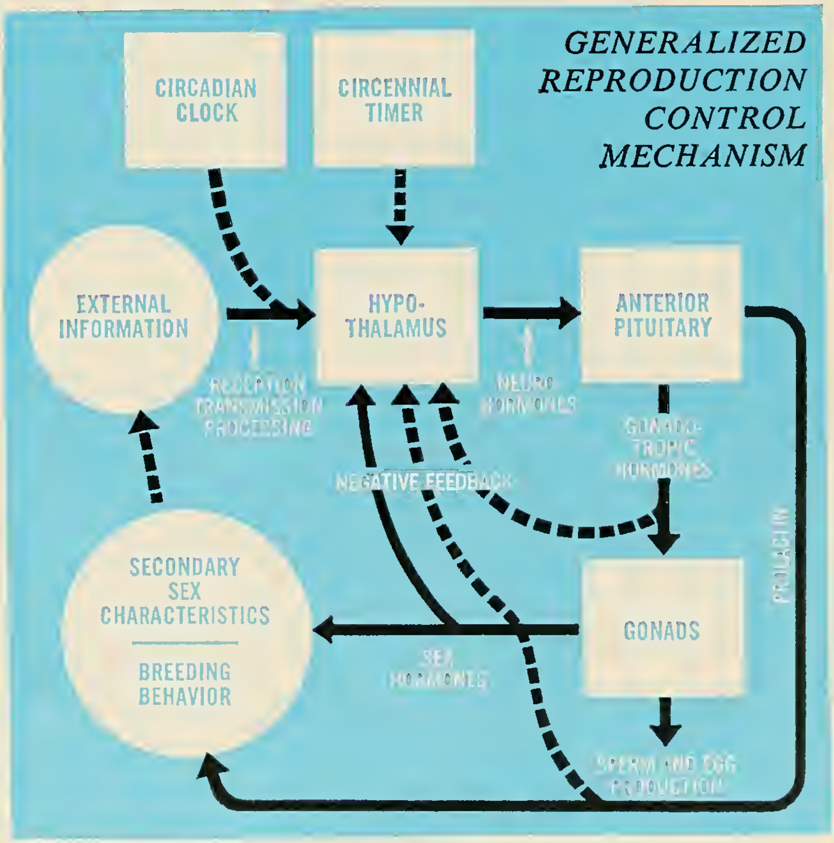
This is one of the most completely photoperiodic birds. When it is held experimentally on daily photoperiods of eight hours or less, there is little or no development of the gonads for at least a year. In addition to its annual reproductive cycle, several other functions are photoperiodically controlled, either directly or indirectly. Immediate and direct responses to long day length include the vernal molt, the hyperphagia (increased appetite and food intake) and fat deposition that precede and accompany spring migration, vernal migratory behavior, testicular development, and the beginning of ovarian development. These events occur only when the birds are subjected, naturally or experimentally, to long daily photoperiods.

An indirect consequence of long-day stimulation in the White-crowned Sparrow is photorefractoriness, which ends, in turn, with the onset of short days. Although the evidence is by no means satisfactory, it is reasonable to hypothesize that postnuptial molt, autumnal fattening, and autumnal migration are also indirect effects of the increasing day length of spring. This sparrow's annual cycle is shown on page 24.

Environmental information other than the duration of the daily photoperiod has only a minor role in the basic timing of the White-crowned Sparrow's reproductive activity. This is understandable when one considers that the bird is migratory, and that the migration itself is adaptive, since it brings the breeding birds to an environment of abundant food and long days. The problem for the individual bird in central California in the early spring is to "know" when to begin the annual development of the reproductive system and when to begin migration. Only day length has a reliable time relationship to the season in Alaska. Our experimental data show that longer spring days cause the release of gonadotropin and thence the development of the reproductive system; they probably also cause the production of prolactin (which, in-



Relation of nervous and endocrine systems in reproduction control are shown above. Arrows pointing upward indicate "negative feed-back" process.

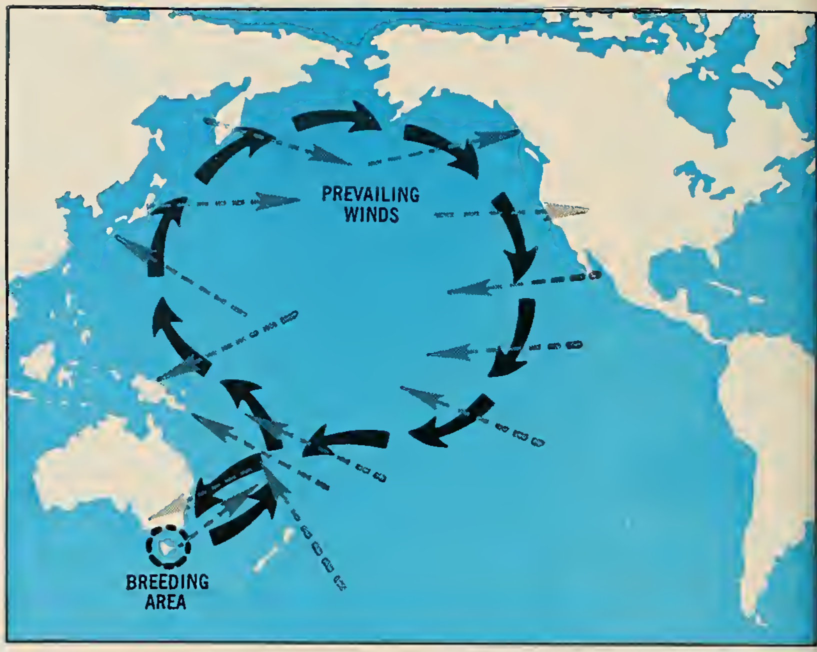


The flow chart suggests relationships between information sources and the reproductive system. Dotted lines are routes that vary according to species.

teracting with other hormones, seems to help induce spring migration).

It is interesting to compare the annual reproductive cycle of the White-crowned Sparrow with that of an equatorial population of a closely related species, the Andean, or Rufous-collared, Sparrow, *Zonotrichia capensis*. The late Alden H. Miller studied a population of Andean Sparrows near the Equator in the Colombian Andes and demonstrated that individual males have two cycles of testicular activity yearly. Although some reproductive activity occurs at all times of the year in this population, there are conspicuous peaks in December-January and May-July that show an adaptation to the semi-annual rainy season with its accompanying increase in insect food. Although details of the Andean Sparrow's control system, and the information used by it, are not known, the system must differ considerably from that of the White-crowned Sparrow, whose rather rigid photoperiodic system may be characteristic of migrants that both breed and winter in middle and high latitudes. Studies on other species give ample testimony that this general type of rigid control system is common. For instance, V. R. Dolnik, of the Leningrad Academy of Science, has demonstrated how photoperiodic responses can vary within a species. He found that male chaffinches of the Kaliningrad region show noticeable testicular development during daily photoperiods as short as nine hours per day, whereas males from the more northerly Leningrad population require nearly eleven hours of light daily for the same development. Yet, if each of the two populations is subjected to day lengths of fourteen hours, testicular growth rates are the same.

Of further interest is the geographically widespread House Sparrow. Although there are migratory populations of this species in Asia, our knowledge of the control of its reproductive cycle is based entirely on the resident population of North America and western Europe. Day length is perhaps most important in the control of the bird's annual testicular cycle. The same is probably true for the ovarian cycle, although it is obvious that, beyond an early stage of development, behavioral and "psychic" elements become significant—as is true in the female reproductive cycle of most species. The House Sparrow's testicular response mechanisms are very different from those of the White-crowned Sparrow. In fact, the mechanisms in these two species were probably evolved independently.



Long migration path of Short-tailed Shearwater is shown with dark arrows. *This bird breeds in the warmer of the two regions between which it migrates.*

Laboratory experiments, together with the observations of many investigators on the natural reproductive cycle, indicate that the control system of the House Sparrow relies to a much greater extent on non-photoperiodic environmental information, such as temperature, than do the control systems of the White-crowned Sparrow and other migrants. Some observations suggest that a crude circennial internal timer may also be involved. As a permanent resident whose reproductive period begins early in spring, the House Sparrow must adjust the development of its reproductive processes according to the temperatures of each spring. The White-crowned Sparrow, on the other hand, uses information from its winter residence in order to begin reproductive development, which will culminate ten weeks later in the breeding area hundreds of miles away. Day length is thus the only source that it can use reliably. The difference between these two species may reflect a general difference in reproductive cycle control between migrants and permanent residents of the middle and high latitudes of the Northern Hemisphere.

There are many observations, in this country and in Britain, of extensions or renewals of breeding in the fall during years that have an unusually favorable temperature or rainfall. One case is the autumnal breeding of the Tricolored Blackbird, *Agelaius tricolor*, in the Sacramento Valley—apparently a response to autumnal rains in an area where irrigation and land management for duck hunting provide abundant nesting and feeding sites.

A particularly opportunistic breeder is the Zebra Finch, *Taeniopygia castanotis*, whose reproductive activity begins immediately after the start of the rainy season. It has a wide distribution throughout the drier parts of Australia. Although annual periodic rains occur in many of these areas, in others the rains are aperiodic. This means that the bird's reproductive activity cannot involve a scheme that uses precise periodic information each year. Rather, it requires a system that initiates such activity rapidly, based on information associated with the beginning of a rainy period. Some individuals of this species may actually breed during both the spring and fall rainy seasons. In the Murrumbidgee irrigation region in New South Wales, where water is continuously available, the Zebra Finch breeds ten

months a year, halting only during the cold months of June and July. In areas of similar climate, but where irrigation is lacking, breeding is restricted to the rainy season.

The Zebra Finch appears to differ significantly from the White-crowned Sparrow. The gonads of some finches are partially developed during the unfavorable, non-breeding period—as though they are "poised" to develop suddenly with the onset of rain. This opportunistic cycle is not an uncommon adaptation among birds in arid parts of Australia. Another striking difference between the two species emerged from observations that Dr. Serventy and I made on captive pairs of Zebra Finches. Under optimal conditions, such pairs will produce many successful clutches without interruption —indicating the absence of an internal mechanism to turn off the gonadotropin-inducing activity of the hypothalamus. Obviously, in this control system there is no refractory period. Unless otherwise inhibited by information from unfavorable external conditions, such as lack of water or low temperatures, it will sustain its reproductive function.

The control of the reproductive cycle of the Red-billed Dioch may be similar to that of the Zebra Finch. For young diochs in Tanzania, the growth of green grass during the rainy season serves as important environmental information. Rainfall itself, or the associated increase in humidity, appears to induce nest building and breeding activity in adults. Curiously, however, although day length does not seem to be an important mechanism when the birds are in the wild, testicular development in captive diochs can be induced by subjecting them to long daily photoperiods. Is this a relict from a time when an ancestral population at a higher latitude was photoperiodic? Or is it a preadaptation that would lead to the development of a naturally photoperiodic population if the environment changed?

It is obvious that birds breeding in middle and high latitudes and wintering in equatorial or transequatorial areas could not have their reproductive cycles photoperiodically controlled as simply as they are in the White-crowned Sparrow, which both breeds and winters in the Northern Hemisphere. An example is the Short-tailed Shearwater. It appears to have an internal circennial timer that is kept in proper phase and period by some (as yet unknown) external annual periodicity.

Another example is the Yellow Wagtail, *Motacilla flava*, whose wintering range is in equatorial Africa. Five subspecies of this bird winter in the eastern Congo—each with its own breeding range in Eurasia and its own schedule of migration, molt, and reproduction. There appears to be no obvious environmental periodicity in the wintering area that could induce gonadal development and spring migration. An endogenous circennial cycle is, however, possible in this case—held in annual periodicity, perhaps, by some annual environmental variable. Or, alternatively, the events of the annual cycle might be timed by decreasing day length after the summer solstice, just as the major events of the annual cycle of the White-crowned Sparrow are timed directly or indirectly by the increasing day length after the winter solstice. As yet, however, there is no proven case among birds in which decreasing day length plays a major role in reproductive-cycle control.

The control systems of reproductive cycles that I have discussed, although small in number, are sufficient to emphasize their extreme differences. Nevertheless, despite our limited knowledge, it seems safe to generalize that the relationships within the "core" of the control system—that is, the hypothalamus, the anterior pituitary, and the gonads—are common and relatively unvarying in birds. The evolution of control systems that insure the greatest probability of success in reproduction has been based on internal and external information used by the hypothalamus; each species tends to use that combination of information that most reliably predicts the approach of its breeding season.

A Short-tailed Shearwater is seen here flying over breeding grounds at night.

Shakespeare in the Bush

by Laura Bohannan

An American anthropologist set out to study the Tiv of West Africa and was taught the true meaning of Hamlet.

Just before I left Oxford for the Tiv in West Africa, conversation turned to the season at Stratford. "You Americans," said a friend, "often have difficulty with Shakespeare. He was, after all, a very English poet, and one can easily misinterpret the universal by misunderstanding the particular."

I protested that human nature is pretty much the same the whole world over; at least the general plot and motivation of the greater tragedies would always be clear—everywhere—although some details of custom might have to be explained and difficulties of translation might produce other slight changes. To end an argument we could not conclude, my friend gave me a copy of *Hamlet* to study in the African bush: it would, he hoped, lift my mind above its primitive surroundings, and possibly I might, by prolonged meditation, achieve the grace of correct interpretation.

It was my second field trip to that African tribe, and I thought myself ready to live in one of its remote sections—an area difficult to cross even on foot. I eventually settled on the hillock of a very knowledgeable old man, the head of a homestead of some hundred and forty people, all of whom were either his close relatives or their wives and children. Like the other elders of the vicinity, the old man spent most of his time performing ceremonies seldom seen these days in the more accessible parts of the tribe. I was delighted. Soon there would be three months of enforced isolation and leisure, between the harvest that takes place just before the rising of the swamps and the clearing of new farms when the water goes down. Then, I thought, they would have even more time to perform ceremonies and explain them to me.

I was quite mistaken. Most of the ceremonies demanded the presence of elders from several homesteads. As the swamps rose, the old men found it too difficult to walk from one homestead to the next, and the ceremonies gradually ceased. As the swamps rose even higher, all activities but one came to an end. The women brewed beer from maize and millet. Men, women, and children sat on their hillocks and drank it.

People began to drink at dawn. By midmorning the whole homestead was singing, dancing, and drumming. When it rained, people had to sit inside their huts: there they drank and sang or they drank and told stories. In any case, by noon or before I either had to join the party or retire to my own hut and my books. "One does not discuss serious matters when there is beer. Come, drink with us." Since I lacked their capacity for the thick native beer, I spent more and more time with *Hamlet*. Before the end of the second month, grace descended on me. I was quite sure that *Hamlet* had only one possible interpretation, and that one universally obvious.

Early every morning, in the hope of having some serious talk before the beer party, I used to call on the old man at his reception hut—a circle of posts supporting a thatched roof above a low mud wall to keep out wind and rain. One day I crawled through the low doorway and found most of the men of the homestead sitting huddled in their ragged cloths on stools, low plank beds, and reclining chairs, warming themselves against the

chill of the rain around a smoky fire. In the center were three pots of beer. The party had started.

The old man greeted me cordially. "Sit down and drink." I accepted a large calabash full of beer, poured some into a small drinking gourd, and tossed it down. Then I poured some more into the same gourd for the man second in seniority to my host before I handed my calabash over to a young man for further distribution. Important people shouldn't ladle beer themselves.

"It is better like this," the old man said, looking at me approvingly and plucking at the thatch that had caught in my hair. "You should sit and drink with us more often. Your servants tell me that when you are not with us, you sit inside your hut looking at a paper."

The old man was acquainted with four kinds of "papers": tax receipts, bride price receipts, court fee receipts, and letters. The messenger who brought him letters from the chief used them mainly as a badge of office, for he always knew what was in them and told the old man. Personal letters for the few who had relatives in the government or mission stations were kept until someone went to a large market where there was a letter writer and reader. Since my arrival, letters were brought to me to be read. A few men also brought me bride price receipts, privately, with requests to change the figures to a higher sum. I found moral arguments were of no avail, since in-laws are fair game, and the technical hazards of forgery difficult to explain to an illiterate people. I did not wish them to think me silly enough to look at any such papers for days on end, and I hastily explained that my "paper" was one of the "things of long ago" of my country.

"Ah," said the old man. "Tell us."

I protested that I was not a storyteller. Storytelling is a skilled art among them; their standards are high, and the audiences critical—and vocal in their criticism. I protested in vain. This morning they wanted to hear a story while they drank. They threatened to tell me no more stories until I told them one of mine. Finally, the old man promised that no one would criticize my style "for we know you are struggling with our language." "But," put in one of the elders, "you must explain what we do not understand, as we do when we tell you our stories." Realizing that here was my chance to prove *Hamlet* universally intelligible, I agreed.

The old man handed me some more beer to help me on with my storytelling. Men filled their long wooden pipes and knocked coals from the fire to place in the pipe bowls; then, puffing contentedly, they sat back to listen. I began in the proper style, "Not yesterday, not yesterday, but long ago, a thing occurred. One night three men were keeping watch outside the homestead of the great chief, when suddenly they saw the former chief approach them."

"Why was he no longer their chief?"

"He was dead," I explained. "That is why they were troubled and afraid when they saw him."

"Impossible," began one of the elders, handing his pipe on to his neighbor, who interrupted, "Of course it wasn't the dead chief. It was an omen sent by a witch. Go on."

Slightly shaken, I continued. "One of these three was a man who knew things"—the closest translation for scholar, but unfortunately it also meant witch. The second elder looked triumphantly at the first. "So he spoke to the dead chief saying, 'Tell us what we must do so you may rest in your grave,' but the dead chief did not answer. He vanished, and they could see him no more. Then the man who knew things—his name was Horatio—said this event was the affair of the dead chief's son, Hamlet."

There was a general shaking of heads round the circle. "Had the dead chief no living brothers? Or was this son the chief?"

"No," I replied. "That is, he had one living brother who became the chief when the elder brother died."

The old men muttered: such omens were matters for chiefs and elders, not for youngsters; no good could come of going behind a chief's back; clearly Horatio was not a man who knew things.

"Yes, he was," I insisted, shooing a chicken away from my beer. "In our country the son is next to the father. The dead chief's younger brother had become the great chief. He had also married his elder brother's widow only about a month after the funeral."

"He did well," the old man beamed and announced to the others, "I told you that if we knew more about Europeans, we would find they really were very like us. In our country also," he added

to me, "the younger brother marries the elder brother's widow and becomes the father of his children. Now, if your uncle, who married your widowed mother, is your father's full brother, then he will be a real father to you. Did Hamlet's father and uncle have one mother?"

His question barely penetrated my mind; I was too upset and thrown too far off balance by having one of the most important elements of *Hamlet* knocked straight out of the picture. Rather uncertainly I said that I thought they had the same mother, but I wasn't sure—the story didn't say. The old man told me severely that these genealogical details made all the difference and that when I got home I must ask the elders about it. He shouted out the door to one of his younger wives to bring his goatskin bag.

Determined to save what I could of the mother motif, I took a deep breath and began again. "The son Hamlet was very sad because his mother had married again so quickly. There was no need for her to do so, and it is our custom for a widow not to go to her next husand until she has mourned for two years."

"Two years is too long," objected the wife, who had appeared with the old man's battered goatskin bag. "Who will hoe your farms for you while you have no husband?"

"Hamlet," I retorted without thinking, "was old enough to hoe his mother's farms himself. There was no need for her to remarry." No one looked convinced. I gave up. "His mother and the great chief told Hamlet not to be sad, for the great chief himself would be a father to Hamlet. Furthermore, Hamlet would be the next chief: therefore he must stay to learn the things of a chief. Hamlet agreed to remain, and all the rest went off to drink beer."

While I paused, perplexed at how to render Hamlet's disgusted soliloquy to an audience convinced that Claudius and Gertrude had behaved in the best possible manner, one of the younger men asked me who had married the other wives of the dead chief.

"He had no other wives," I told him.

"But a chief must have many wives! How else can he brew beer and prepare food for all his guests?"

I said firmly that in our country even chiefs had only one wife, that they had servants to do their work, and that they paid them from tax money.

It was better, they returned, for a chief to have many wives and sons who would help him hoe his farms and feed his people; then everyone loved the chief who gave much and took nothing—taxes were a bad thing.

I agreed with the last comment, but for the rest fell back on their favorite way of fobbing off my questions: "That is the way it is done, so that is how we do it."

I decided to skip the soliloquy. Even if Claudius was here thought quite right to marry his brother's widow, there remained the poison motif, and I knew they would disapprove of fratricide. More hopefully I resumed, "That night Hamlet kept watch with the three who had seen his dead father. The dead chief again appeared, and although the others were afraid, Hamlet followed his dead father off to one side. When they were alone, Hamlet's dead father spoke."

"Omens can't talk!" The old man was emphatic.

"Hamlet's dead father wasn't an omen. Seeing him might have been an omen, but he was not." My audience looked as confused as I sounded. "It *was* Hamlet's dead father. It was a thing we call a 'ghost.' " I had to use the English word, for unlike many of the neighboring tribes, these people didn't believe in the survival after death of any individuating part of the personality.

"What is a 'ghost?' An omen?"

"No, a 'ghost' is someone who is dead but who walks around and can talk, and people can hear him and see him but not touch him."

They objected. "One can touch zombis."

"No, no! It was not a dead body the witches had animated to sacrifice and eat. No one else made Hamlet's dead father walk. He did it himself."

"Dead men can't walk," protested my audience as one man.

I was quite willing to compromise. "A 'ghost' is the dead man's shadow."

But again they objected. "Dead men cast no shadows."

"They do in my country," I snapped.

The old man quelled the babble of disbelief that arose immediately and told me with that insincere, but courteous, agreement one extends to the fancies of the young, ignorant, and superstitious, "No doubt in your country the dead can also

walk without being zombis." From the depths of his bag he produced a withered fragment of kola nut, bit off one end to show it wasn't poisoned, and handed me the rest as a peace offering.

"Anyhow," I resumed, "Hamlet's dead father said that his own brother, the one who became chief, had poisoned him. He wanted Hamlet to avenge him. Hamlet believed this in his heart, for he did not like his father's brother." I took another swallow of beer. "In the country of the great chief, living in the same homestead, for it was a very large one, was an important elder who was often with the chief to advise and help him. His name was Polonius. Hamlet was courting his daughter, but her father and her brother . . . [I cast hastily about for some tribal analogy] warned her not to let Hamlet visit her when she was alone on her farm, for he would be a great chief and so could not marry her."

"Why not?" asked the wife, who had settled down on the edge of the old man's chair. He frowned at her for asking stupid questions and growled, "They lived in the same homestead."

"That was not the reason," I informed them. "Polonius was a stranger who lived in the homestead because he helped the chief, not because he was a relative."

"Then why couldn't Hamlet marry her?"

"He could have," I explained, "but Polonius didn't think he would. After all, Hamlet was a man of great importance who ought to marry a chief's daughter, for in his country a man could have only one wife. Polonius was afraid that if Hamlet made love to his daughter, then no one else would give a high price for her."

"That might be true," remarked one of the shrewder elders, "but a chief's son would give his mistress's father enough presents and patronage to more than make up the difference. Polonius sounds like a fool to me."

"Many people think he was," I agreed. "Meanwhile Polonius sent his son Laertes off to Paris to learn the things of that country, for it was the homestead of a very great chief indeed. Because he was afraid that Laertes might waste a lot of money on beer and women and gambling, or get into trouble by fighting, he sent one of his servants to Paris secretly, to spy out what Laertes was doing. One day Hamlet came upon Polonius's daughter Ophelia. He behaved so oddly he frightened her. Indeed"—I was fumbling for words to express the dubious quality of Hamlet's madness—"the chief and many others had also noticed that when Hamlet talked one could understand the words but not what they meant. Many people thought that he had become mad." My audience suddenly became much more attentive. "The great chief wanted to know what was wrong with Hamlet, so he sent for two of Hamlet's age mates [school friends would have taken long explanation] to talk to Hamlet and find out what troubled his heart. Hamlet, seeing that they had been bribed by the chief to betray him, told them nothing. Polonius, however, insisted that Hamlet was mad because he had been forbidden to see Ophelia, whom he loved."

"Why," inquired a bewildered voice, "should anyone bewitch Hamlet on that account?"

"Bewitch him?"

"Yes, only witchcraft can make anyone mad, unless, of course, one sees the beings that lurk in the forest."

I stopped being a storyteller, took out my notebook and demanded to be told more about these two causes of madness. Even while they spoke and I jotted notes, I tried to calculate the effect of this new factor on the plot. Hamlet had not been exposed to the beings that lurk in the forests. Only his relatives in the male line could bewitch him. Barring relatives not mentioned by Shakespeare, it had to be Claudius who was attempting to harm him. And, of course, it was.

For the moment I staved off questions by saying that the great chief also refused to believe that Hamlet was mad for the love of Ophelia and nothing else. "He was sure that something much more important was troubling Hamlet's heart."

"Now Hamlet's age mates," I continued, "had brought with them a famous storyteller. Hamlet decided to have this man tell the chief and all his homestead a story about a man who had poisoned his brother because he desired his brother's wife and wished to be chief himself. Hamlet was sure the great chief could not hear the story without making a sign if he was indeed guilty, and then he would discover whether his dead father had told him the truth."

The old man interrupted, with deep cunning, "Why should a father lie to his son?" he asked.

I hedged: "Hamlet wasn't sure that it really was his dead father." It was impossible to say anything, in that language, about devil-inspired visions.

"You mean," he said, "it actually was an omen, and he knew witches sometimes send false ones. Hamlet was a fool not to go to one skilled in reading omens and divining the truth in the first place. A man-who-sees-the-truth could have told him how his father died, if he really had been poisoned, and if there was witchcraft in it; then Hamlet could have called the elders to settle the matter."

The shrewd elder ventured to disagree. "Because his father's brother was a great chief, one-who-sees-the-truth might therefore have been afraid to tell it. I think it was for that reason that a friend of Hamlet's father—a witch and an elder—sent an omen so his friend's son would know. Was the omen true?"

"Yes," I said, abandoning ghosts and the devil; a witch-sent omen it would have to be. "It was true, for when the storyteller was telling his tale before all the homestead, the great chief rose in fear. Afraid that Hamlet knew his secret he planned to have him killed."

The stage set of the next bit presented some difficulties of translation. I began cautiously. "The great chief told Hamlet's mother to find out from her son what he knew. But because a woman's children are always first in her heart, he had the important elder Polonius hide behind a cloth that hung against the wall of Hamlet's mother's sleeping hut. Hamlet started to scold his mother for what she had done."

There was a shocked murmur from everyone. A man should never scold his mother.

"She called out in fear, and Polonius moved behind the cloth. Shouting, 'A rat!' Hamlet took his machete and slashed through the cloth." I paused for dramatic effect. "He had killed Polonius!"

The old men looked at each other in supreme disgust. "That Polonius truly was a fool and a man who knew nothing! What child would not know enough to shout, 'It's me!' " With a pang, I remembered that these people are ardent hunters, always armed with bow, arrow, and machete; at the first rustle in the grass an arrow is aimed and ready, and the hunter shouts "Game!" If no human voice answers immediately, the arrow speeds on its way. Like a good hunter Hamlet had shouted, "A rat!"

I rushed in to save Polonius's reputation. "Polonius did speak. Hamlet heard him. But thought it was the chief and wished to kill him avenge his father. He had meant to kill him earl that evening. . . ." I broke down, unable to descri to these pagans, who had no belief in individu afterlife, the difference between dying at on prayers and dying "unhousell'd, disappointed, u aneled."

This time I had shocked my audience seriousl "For a man to raise his hand against his fathe brother and the one who has become his fathe that is a terrible thing. The elders ought to such a man be bewitched."

I nibbled at my kola nut in some perplexity, th pointed out that after all the man had killed Har let's father.

"No," pronounced the old man, speaking less me than to the young men sitting behind the elde "If your father's brother has killed your fathe you must appeal to your father's age mates; *th* may avenge him. No man may use violence again his senior relatives." Another thought struck hir "But if his father's brother had indeed been wick enough to bewitch Hamlet and make him mad th would be a good story indeed, for it would be h fault that Hamlet, being mad, no longer had a sense and thus was ready to kill his father's brother

There was a murmur of applause. *Haml* was again a good story to them, but it n longer seemed quite the same story to m As I thought over the coming complicatio of plot and motive, I lost courage and decided t skim over dangerous ground quickly.

"The great chief," I went on, "was not sor that Hamlet had killed Polonius. It gave him reason to send Hamlet away, with his two treac erous age mates, with letters to a chief of a f country, saying that Hamlet should be killed. B Hamlet changed the writing on their papers, so th the chief killed his age mates instead." I encour tered a reproachful glare from one of the me whom I had told undetectable forgery was n merely immoral but beyond human skill. I looke the other way.

"Before Hamlet could return, Laertes cam back for his father's funeral. The great chief tol him Hamlet had killed Polonius. Laertes swore t kill Hamlet because of this, and because his siste

Ophelia, hearing her father had been killed by the man she loved, went mad and drowned in the river."

"Have you already forgotten what we told you?" The old man was reproachful. "One cannot take vengeance on a madman; Hamlet killed Polonius in his madness. As for the girl, she not only went mad, she was drowned. Only witches can make people drown. Water itself can't hurt anything. It is merely something one drinks and bathes in."

I began to get cross. "If you don't like the story, I'll stop."

The old man made soothing noises and himself poured me some more beer. "You tell the story well, and we are listening. But it is clear that the elders of your country have never told you what the story really means. No, don't interrupt! We believe you when you say your marriage customs are different, or your clothes and weapons. But people are the same everywhere; therefore, there are always witches and it is we, the elders, who know how witches work. We told you it was the great chief who wished to kill Hamlet, and now your own words have proved us right. Who were Ophelia's male relatives?"

"There were only her father and her brother." Hamlet was clearly out of my hands.

"There must have been many more; this also you must ask of your elders when you get back to your country. From what you tell us, since Polonius was dead, it must have been Laertes who killed Ophelia, although I do not see the reason for it."

We had emptied one pot of beer. and the old men argued the point with slightly tipsy interest. Finally one of them demanded of me, "What did the servant of Polonius say on his return?"

With difficulty I recollected Reynaldo and his mission. "I don't think he did return before Polonius was killed."

"Listen," said the elder, "and I will tell you how it was and how your story will go, then you may tell me if I am right. Polonius knew his son would get into trouble, and so he did. He had many fines to pay for fighting, and debts from gambling. But he had only two ways of getting money quickly. One was to marry off his sister at once, but it is difficult to find a man who will marry a woman desired by the son of a chief. For if the chief's heir commits adultery with your wife, what can you do? Only a fool calls a case against a man who will someday be his judge. Therefore Laertes had to take the second way: he killed his sister by witchcraft, drowning her so he could secretly sell her body to the witches."

I raised an objection. "They found her body and buried it. Indeed Laertes jumped into the grave to see his sister once more—so, you see, the body was truly there. Hamlet, who had just come back, jumped in after him."

"What did I tell you?" The elder appealed to the others. "Laertes was up to no good with his sister's body. Hamlet prevented him, because the chief's heir, like a chief, does not wish any other man to grow rich and powerful. Laertes would be angry, because he would have killed his sister without benefit to himself. In our country he would try to kill Hamlet for that reason. Is this not what happened?"

"More or less," I admitted. "When the great chief found Hamlet was still alive, he encouraged Laertes to try to kill Hamlet and arranged a fight with machetes between them. In the fight both the young men were wounded to death. Hamlet's mother drank the poisoned beer that the chief meant for Hamlet in case he won the fight. When he saw his mother die of poison, Hamlet, dying, managed to kill his father's brother with his machete."

"You see, I was right!" exclaimed the elder.

'That was a very good story," added the old man, "and you told it with very few mistakes. There was just one more error, at the very end. The poison Hamlet's mother drank was obviously meant for the survivor of the fight, whichever it was. If Laertes had won, the great chief would have poisoned him, for no one would know that he arranged Hamlet's death. Then, too, he need not fear Laertes' witchcraft; it takes a strong heart to kill one's only sister by witchcraft.

"Sometime," concluded the old man, gathering his ragged toga about him, "you must tell us some more stories of your country. We, who are elders, will instruct you in their true meaning, so that when you return to your own land your elders will see that you have not been sitting in the bush, but among those who know things and who have taught you wisdom."

SUMMERS IN PENOBSCOT COUNTRY

by Eliot Porter

A dedicated photographer recalls the Maine coast as he has known it.

In 1912, when I was ten years old, my father bought Great Spruce Head Island in Penobscot Bay on the coast of Maine. Our lives, my brother's and sister's and mine, were from the very first summer determined by the sea.

We lived by lunar as much as by solar time. Before daylight-saving time had been devised, we set our clocks ahead in order to enjoy more fully the daylight hours. We gathered shells along the high-tide wrack: powder-blue and purple mussels in all sizes that nest together in compact families, pale-green sea urchins washed clean of their spines, and the brilliant orange carapaces of crabs that live in the rockweed of the littoral zone. We collected starfish, sun stars, and sand dollars, and after boiling them to coagulate them, dried them under the kitchen stove. From the shallow edge of the sea we dredged up anemones, sea cucumbers, limpets, and calcareous algae. The names of all these creatures were explained to us by our father, who took an even greater interest than we in this ever-present museum of marine biology.

Great Spruce Head Island is in the middle of Penobscot Bay, in a group of islands of which it is the third largest. On a chart of the bay, it somewhat resembles a molar tooth, its crown pointing north, roots south. The toothlike configuration is caused by a long, narrow inlet that separates the southern half into two lobes, or roots. The smaller root is a wooded ridge that terminates in a tombolo, or gravel bar. Littered with silver driftwood, mussel shells, and blackened strands of seaweed, the sharp-backed ridge slopes off on either side into smooth beaches. The tombolo joins the main island to a rocky, tree-covered islet.

The inlet dividing the lobes is a cove a half mile long, ending in a tidal basin. At low tide the cove is completely empty, exposing a mud bottom. At the end of the cove, when it is full, the water stands seven or eight feet deep. For three generations, since our first year on the island, the cove has been a swimming hole for children and adults alike. Time has caused few physical changes on the cove; the trees and rocks remain the same; we dive from the same place on the bank as we did when we were children; and the summer sun still warms the flooding tide on a hot July afternoon.

Around the perimeter of the island, in the woods above the shore, the fallen needles of spruce and balsam form a brown, springy bed of forest duff that fills the hollows between the loose stones and exposed roots of the larger trees. There *Maianthemum*—wild lily-of-the-valley—and star-flower are the first flowers to bloom in spring. There also, in the grass on exposed promontories, where juniper lies flat over the jagged rocks and orange lichen grows in scaly patches, are crows' scattered middens.

From the aggressive gulls the crows retreat with their catch to the comparative safety of the higher and wooded ground, there to feast undisturbed. All along the path that follows the island's shore are strewn the fragments of marine animals. In places, accumulations of these remains suggest a communal banquet where crows had gathered—if not to share the repast collected from the sea, then at least to share the society of other crows.

There is a place of trees . . . gray with lichen.
I have walked there
thinking of old days.
Ezra Pound, *Provincia Deserta*

The great rhythms of nature, to-day so dully disregarded, wounded even, have here their spacious and primeval liberty....

Henry Beston, *The Outermost House*

Live in Nature, and you will soon see that for all its nonhuman rhythm, it is no cave of pain.

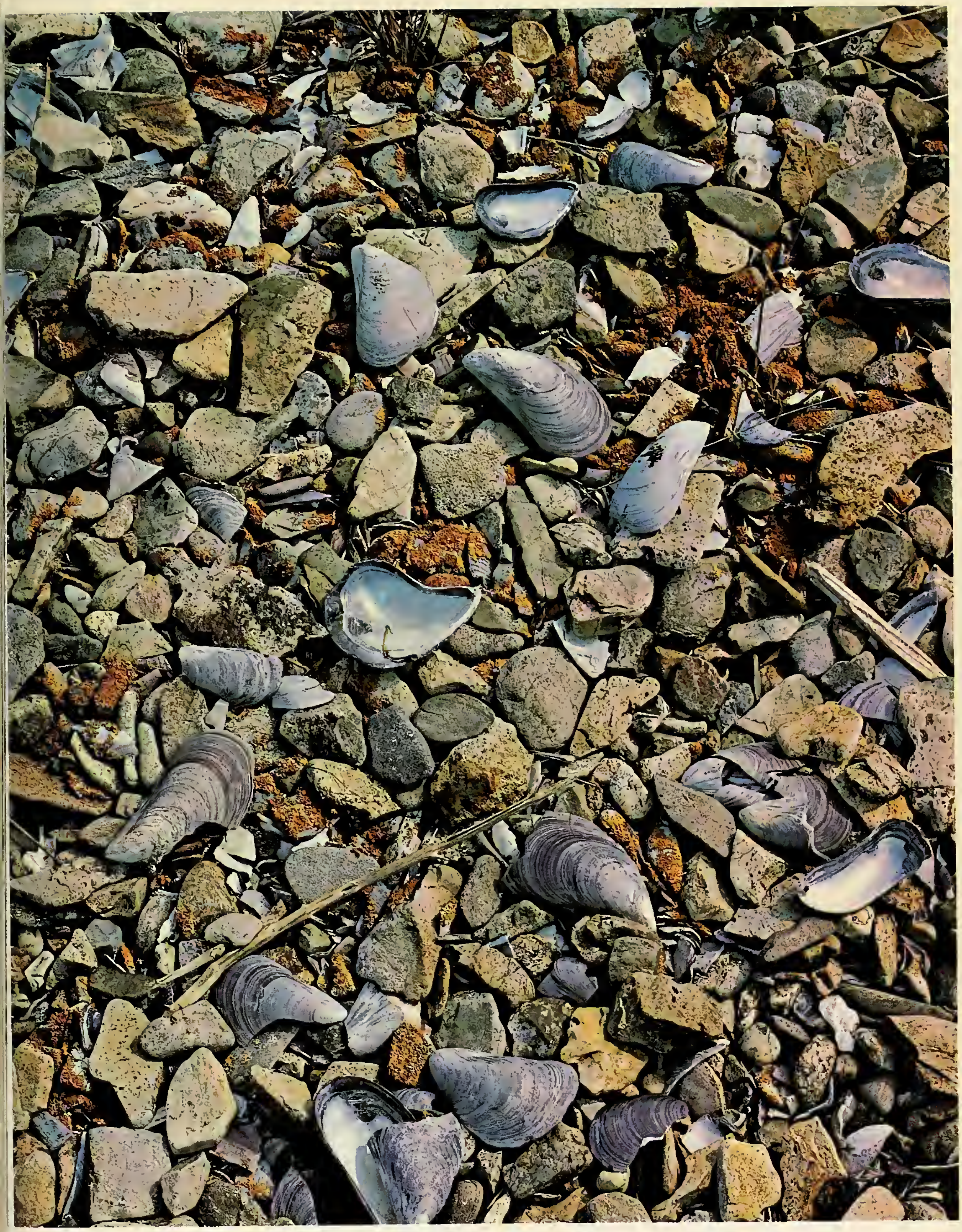
Henry Beston, *The Outermost House*

My life is like a stroll upon the beach,
As near the ocean's edge as I can go;
My tardy steps its waves sometimes o'erreach,
Sometimes I stay to let them overflow.

My sole employment 'tis, and scrupulous care,
To place my gains beyond the reach of tides,—
Each smoother pebble, and each shell more rare,
Which Ocean kindly to my hand confides.

I have but few companions on the shore:
They scorn the strand who sail upon the sea;
Yet oft I think the ocean they've sailed o'er
Is deeper known upon the strand to me.

Henry David Thoreau, *The Fisher's Boy*



Here the people seem to possess the secret of tranquillity and to live lives of more than surface contentment. That is rare today. Perhaps it is only by going up the old back roads leading to the lost little hamlets of the mountains or the seagirt islands and peninsulas of the world that you can still find it. Perhaps even in such places it has not long to last.

Louise Dickinson Rich, *The Peninsula*

What seas what shores what granite
islands towards my timbers
And woodthrush calling through the fog
T. S. Eliot, *Marina*

Often the island was shrouded in fog. We moved in a grayness, out of which came, from somewhere, the distant cawing of a crow, the echoed screaming of a gull, or the putting sound of a gasoline motor. But such sounds were not really an intrinsic part of our surroundings. Only those made by the fog itself belonged to us: the continual dripping from leaves and wet branches, the faint tricklings, and the less frequent, sudden, cascading shower started by some overladen drop that finally broke loose from its mooring. Sometimes the fog lingered all day; often the sun burned through by noon. Our nearest neighboring islands then loomed through the mist larger than they should appear, or they were capped with lenticular clouds of fog while we were hot and humid in brilliant sunshine.

Before many summers had gone by I learned much about the fog—the way it transmits sounds, and the way it alters the appearance of familiar shores. I could take a small boat out and not get lost, although I might not fetch up exactly where I had planned. I could set out for an island four miles away to collect the mail and find my way, if need be, without a compass.

In recent years, having moved to New Mexico, I have not been back to the island often. But the buried images have not lost any of their sharpness; they have merely been tucked away out of sight to permit a freer play for contemporary impressions. Before going to the Southwest with children of my own, I built a house on the island, and life acquired new dimensions. I became more seriously interested in photography. My subjects expanded from birds to the island itself, to the whole bay with its towns, houses, people, and boats. The songbirds, however, continued to be my special preoccupation. To find and photograph these birds, my ultimate aim, I needed to be able to identify them by their songs, their plumage, and their habits. Furthermore, I needed to remember through the fall and winter what I had learned in the warmer months. Gradually, however, recognizing the birds by sight or song and tracking them to their nests became an end in itself, and as exciting an activity as photography.

The fever to search out birds, whether new species or old friends, is a kind of curiosity completely understood only by those people who are so often derisively referred to as bush shakers and bird watchers. Brewed from a mixture of scientific curiosity and esthetic appreciation, this activity gives to those who engage in it something of the wonder and satisfaction enjoyed by artists and scientists.

During a family reunion in the summer of 1963, I re-experienced much that I had previously learned about the island, and I found many sensations heightened and made perceivable by my years of absence. I realized that the young people did not enjoy the island as my generation had. Their interests were directed by a more complex technology, which brought the island closer to urban civilization. With that closeness, that loss of remoteness, the island's wildness was ebbing away.

But there is hope that the wildness of the Maine islands may still be saved, even though their remoteness can never be recovered. To preserve them, I believe they should be acquired as a park, a natural preserve, or wild lands, and set aside with their bird and plant life. They should be kept undisturbed even by well-meaning managers who so often cannot resist the temptation to "improve" the lands in their custody. There should be no foresting and no trail building on these small islands, and no control of the animal life established on them. They would be accessible to whoever has a boat or can hire a boat to go to them. Berries could be gathered in their meadows and clams dug around their shores, but otherwise they should be left to follow their natural cycles of change without interference. If trees blow down, they should be left blown down, and if insects infest them, the infestation should be allowed to run its normal course. Lobstermen and fishermen would still enjoy the freedom of the bay, and sailors and yachtsmen would still visit the same harbors in their cruises. It would be an experiment in non-management.

Improbable Mollusk

These small nudibranchs float upside down, use their prey's weapon in their own defense, and mate hermaphroditically.

In this unusual sequence of photographs, the courtship of Glaucus atlanticus *begins, above, as the inch-long animals touch with their decorative appendages, which serve not only as gills but as aids in flotation. As the mating ac*

by WILLIAM M. STEPHENS

During winter along Florida's lower east coast, each siege of strong north winds brings to inshore waters and beaches a host of blue-water animals from the nearby Gulf Stream. The most common and conspicuous of these are the colonial coelenterates known as siphonophores, of which the best-known is probably the Portuguese man-of-war. Occasionally other, less conspicuous forms move ashore with the great fleets of siphonophores. Some of these are small, carnivorous mollusks that feed on siphonophore tentacles.

One of the rarer of these pelagic mollusks is the nudibranch *Glaucus atlanticus*. Only about an inch in length, *Glaucus* spends its life floating upside down on the surface of the deep sea. Actually, it clings to the underside of the surface film, just as most other nudibranchs cling to the substrate. The upper, or belly, surface of the animal is iridescent silver and blue, while the lower side, or back, is pearly white. Along each side are three ornamental processes that radiate outward like delicate fans. These are called cerata, and they function somewhat like gills as an aid to respiration. They are believed also to aid in flotation. When one observes *Glaucus* feeding or mating, it is impossible to escape the conclusion that the cerata of *Glaucus* also perform admirably as substitutes for arms and hands. These marvelous processes have yet another function. Like some of the land-bound nudibranchs, *Glaucus* has the incredible ability to utilize, in its own defense, some of the stinging cells of the coelenterates it eats. In some remarkable way it can pass these nematocysts, undischarged and still potent, through its mouth and digestive tract to the lateral processes. Now the nudibranch, if molested, can sting any predator.

Found in all tropical, temperate, and subarctic seas, nudibranchs are among the most gaily colored and delicately formed animals on earth. *Glaucus atlanticus* is found in all warm seas. It is evidently exceedingly abundant, as literally thousands of specimens may occasionally wash ashore. But because its exact distribution is unknown, and its movements unpredictable, and since it dies soon after being stranded, it is rarely seen alive.

On two occasions this past winter a colleague and I found living specimens of *Glaucus* coming ashore at Key Biscayne, near Miami, Florida. On each occasion we collected several dozen animals and kept them alive for up to a week in aquariums. On January 2, 1966, we were fortunate to observe seven couples of *Glaucus* (all collected the day before) in reciprocal copulation. Each individual is hermaphroditic, and mates fertilize each other's eggs simultaneously. In one observed instance the mating act continued for about ten minutes.

During this period we saw eggs coming from both animals. Minute strings of eggs were entangled in the cerata of some of the animals after they mated, and one individual had a string of eggs extruding from its aperture. It jerked itself spasmodically and broke the string, which sank to the bottom of the aquarium. (Some biologists have suggested that *Glaucus* lays its eggs on the siphonophores *Velella* and *Porpita*, but our observations do not bear this out. Although floating specimens of both siphonophores were present in the aquariums where the mating took place, the nudibranchs used them only for food and ignored them during spawning.)

After spawning was concluded, fourteen specimens and their fertilized eggs were turned over to Dr. Harding Owre at the Institute of Marine Science, University of Miami. In the laboratory the embryos hatched as free-swimming veliger larvae on the fourth day. In this larval stage the tiny nudibranchs were complete with a coiled shell, a foot, and an operculum. Some of the larvae lived for two weeks, but died before metamorphosing into shell-less young adults. All the adult animals died within a week after spawning.

continues, the two animals simultaneously fertilize each other's eggs. Mating has been observed to last for as long as ten minutes. Shown in the photograph below is the final position assumed by Glaucus *before the act of mating ends.*

SKY REPORTER

A survey of various kinds of sky maps and suggestions on usage

By Thomas D. Nicholson

The sky map and the celestial calendar for August and September (*page 49*) were particularly difficult to prepare and, for some readers, may even be a little difficult to follow. The problem was to show the changing position of the moon in the evening sky for these two months, for there are three full moons during the period, each one displaced some distance to the east among the stars from the previous period. It is difficult to describe properly, in a short space, the interesting grouping of planets, the manner in which the group changes over the two months, and the movement of the moon through the morning planets in mid-August and mid-September. This problem is further complicated because the planets and phases of the moon do not appear on the sky map, for they are in the sky of the early morning.

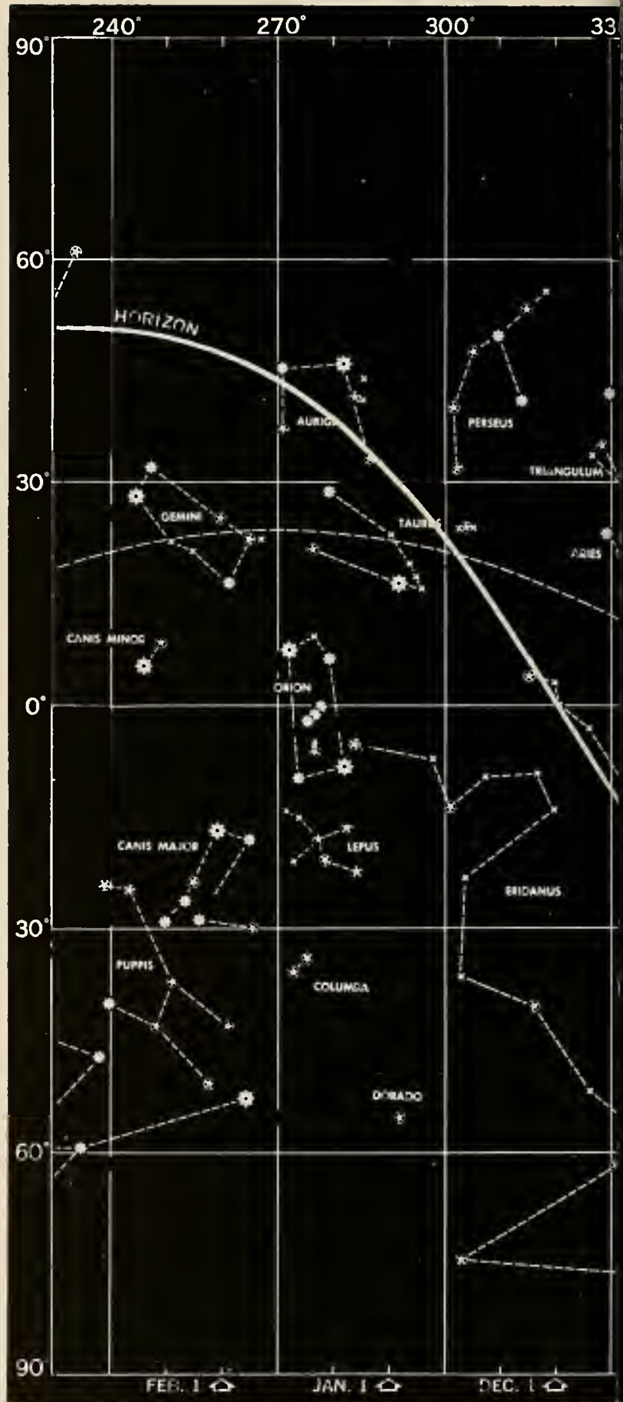
Hence this space will be devoted to a more complete description of the events outlined on the calendar page. We will also review the nature of the sky map and the way to use it—partially in response to readers' queries.

There are many ways in which a map of the stars may be prepared. In general, a sky map may be designed to show the stars from the outside looking down, as an earth map is prepared, or from below looking up, as the stars appear from the surface of the earth. It may show all the stars of the sky or, as in the navigational map on this page, all the stars most important to navigators. Or it may contain all the stars in one or the other hemisphere. It may also show only the stars that are visible from a specific location at a specific time and date.

We have prepared our maps to show the stars as we look up at them from the earth's surface and have included those that could be seen from any point on latitude 40 degrees north at a specific time (between 9:00 and 10:00 P.M.) on the middle date of each month (mid-July and mid-September in the two summer issues).

The center of the circular map represents the zenith, the point in the sky directly overhead, and the circumference of the map represents the horizon, which you see around you. The altitude (height above the horizon) of a star in the sky may be judged by its distance from the circumference toward the center. A star shown on the map as one-third of the distance between the east point on the chart and the center will be found in the same position in the sky.

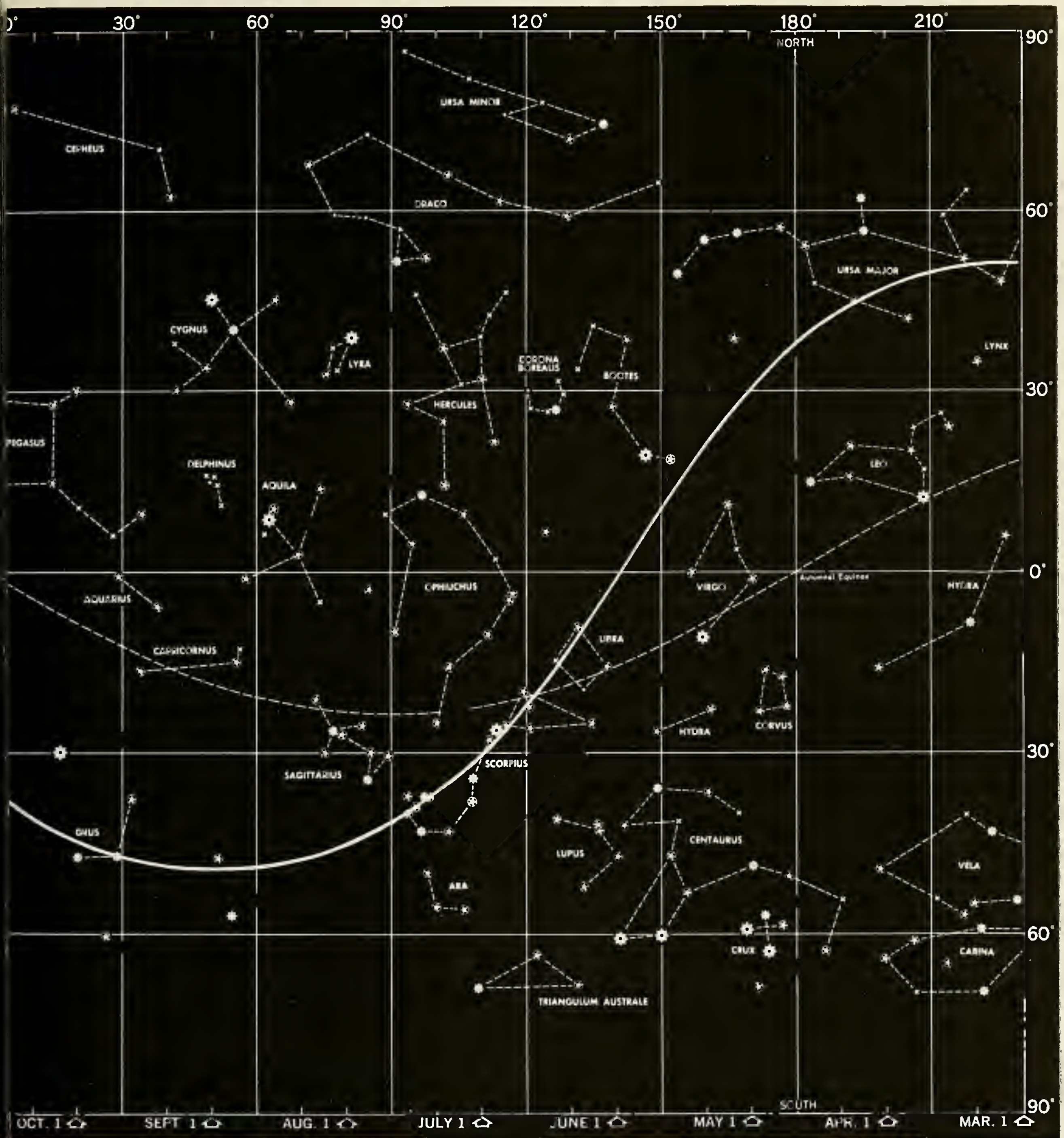
Since the map is arranged to represent the stars as we look up at them, the compass directions are necessarily opposite to those on earth, where compass directions are arranged as if one were looking down. If you hold the



sky map over your head, with north facing toward the North Star, you will see the orientation of the compass points in relation to the cardinal points on the horizon.

A more convenient way to use the map, however, is to hold it vertically, with the compass direction at the bottom. Thus, facing north, with the word "north" at the bottom, the stars on the map—from the center downward—will match the stars in the sky. Because it is best used this way, maps of this type are often called "roll-around" maps. (Also, notice that the lettering is right side up only when the maps are used in this manner.)

Because the earth is continually moving around the sun, facing us toward progressively different directions among the stars each night, a map prepared for 9:00



Horizon as seen from latitude 40° N. is shown by solid curve, which should be viewed as movable. By matching lowest point of curve to any date on bottom margin of map, horizon is set for sky visible at 10:00 P.M. on that date.

›.M. on a certain date will not be applicable at 9:00 P.M. ifteen days later, but will apply one hour earlier than):00 P.M. on that later date. Thus a choice of times and lates is given. At other times, earlier or later than those ndicated, the stars of the sky will be displaced somewhat 'rom the positions shown on the maps; those on the ›astern horizon will be lower, and those on the western ıorizon higher, at an earlier hour.

Observers who might be at a latitude north of 40 legrees north will see the stars displaced from the posiions shown on the "Sky Reporter" maps. Those on the ıorthern horizon will appear higher, and those on the outhern horizon lower, than indicated on the maps. The opposite will be true for those who are observing he sky from a spot south of latitude 40 degrees north.

Because "Sky Reporter" maps are prepared for a specific time and date, the positions of the moon and planets obviously can be shown only if they are in the sky at that time. Planets that may be prominent in the early evening sky are low in the west and, like those in the morning sky, cannot be shown. Venus presents an outstanding example of the price we pay for the basic convenience of this type of map. Since it always appears in the sky close to the sun, it is seldom visible at 9:00 or 10:00 P.M. When Venus is a brilliant evening star, it

has set by that time. If the maps were prepared for an earlier hour, when Venus was visible, they could not be used for as long a period of the evening. Of course, Venus as a morning star must always be omitted. The same restriction applies to showing the moon's position on the maps. The moon can only be shown when it is in those phases that would normally be visible at 9:00 or 10:00 P.M. The very early crescent moon and, in general, the phases after the full moon cannot be represented.

With the exception of Saturn, none of the planets in the summer sky can be shown on our sky map. Yet, Venus, Mars, and Jupiter, and Mercury to a lesser extent, are gathering in the morning sky of early August, and will continue to be seen all through August and September by anyone who wants to get up early enough.

Of this summer's planets, Venus has been visible the longest time. It has been a morning star since February, growing brighter and rising earlier; now it is growing dimmer and rising later as it moves closer to the sun. It is still bright enough (magnitude −3.3) and far enough from the sun to be seen for at least an hour in the dawn sky a little to the north of east.

The second planet of the group, Mars, has been dawdling in the morning sky since the end of April—too close to the sun to be seen easily. Now, in August and September, it can be found from one to two hours before it fades into the twilight, even though it is somewhat difficult to locate.

Jupiter has also been lost in the sun's vicinity for about two months, but it moved into the morning sky in early July, and can easily be seen, at magnitude −1.4, for an hour or two in the darkness and early dawn.

On the morning of August 1, Venus should be the first planet visible in the morning sky, a little north of east, just before dawn breaks. Mars, much fainter, will rise behind it: then will come Jupiter, about midway in brightness between the other two planets. During the first two weeks of August, these three planets will reverse their positions in an interesting manner, as the conjunctions referred to in the sky calendar occur one by one.

In the morning sky of August 14, the late crescent moon will move into the planetary group. About two hours before sunrise, it will be above Jupiter, with the planet standing off its lower horn, and Mars below and to the left. Slowly, the moon will move past Jupiter toward Mars, but the rising sun will brighten the sky and cause Mars to disappear before the moon can pass it.

For the balance of August and on into September, Jupiter, Mars, and Venus will be stretched out in line, and will rise in that order, continually drawing farther apart. Jupiter and Mars will rise earlier each morning, and Venus later. By the end of September, Venus may be difficult to find, but Jupiter and Mars will be easier.

In September, the late crescent moon will move into the vicinity of Jupiter and Mars, and this time they will be higher and easier to see. On the morning of September 10, Jupiter and Mars will be to the left and below the moon; on the 11th, the moon will be above and between the two planets; and on the 12th, both Mars and Jupiter will be to the right of the moon.

As we have said, only the evening phases of the moon —that is, those that are observable at about 9:00 or 10:00 P.M.—can be pictured. (However, the moon's position relative to the stars, planets, and sun can be shown on the navigational map of the entire sky seen on pages 46-47.) The positions of the moon shown on the August-September sky map may seem especially confusing, however, because there happen to be three full moons during this two-month period. Thus the full moon and gibbous moon in early August, the phases from crescent to full to gibbous in late August and early September, and the phases up to the full moon of late September must all be represented. The moon symbols shown on the map, therefore, include parts of three different cycles of phases, all shown along the region of the map where the ecliptic (and, approximately, the plane of the moon's orbit) crosses our evening summer sky.

As the moon changes its phase from night to night, the position it seems to occupy among the stars also changes, at the rate of about 13 degrees eastward through the stars. This distance represents about 24 or 25 lunar diameters, so that the moon actually seems to shift to the left by about one lunar diameter each hour. This effect is pronounced enough so it can be seen easily by the eye if the moon is near some bright star whose position can be used for comparison. An interesting example of this can be observed on the evening of August 23 and again on the evening of September 19.

On both of these evenings, the moon, near first quarter, will appear among the bright stars of the constellation Scorpius, in the southern sky as darkness comes on. During the next several hours, both the moon and the stars will appear to drift slowly westward, as a result of the eastward rotation of the earth. But if you watch that westward motion for a few hours, you will see that the stars seem to be moving more rapidly than the moon.

Two other interesting lunar events take place in September of this year. Each month, at new moon and full moon, spring tides occur, causing high tides to be greater than at any other times during the month. This September, the moon arrives at perigee (the point at which it is nearest to the earth) within a few hours of the occurrence of new moon on September 14. This perigee happens to be a very close one—221,800 miles, which is about as close to the earth as the moon ever gets. The proximity will cause the spring tide of September 14 to be even higher.

Finally, the full moon of September 29 will be this year's harvest moon—the one that occurs nearest to the autumnal equinox. As it rises in the early evening, it is located near the part of the ecliptic that is most nearly parallel to the horizon. Its orbital motion, as a result, takes it eastward from night to night, almost parallel to the horizon. Thus, for several nights before and after September 29, the nearly full moon will appear to rise at about the same time—near sunset—and bright moonlight will dominate the early part of the evening. Since this phenomenon always accompanies the full moon nearest to September 21, it provides useful early evening light during the harvest season, and hence it is known as the harvest moon.

DR. NICHOLSON, the regular author of this column, is also Chairman of the AMERICAN MUSEUM-HAYDEN PLANETARIUM.

THE SKY IN AUGUST AND SEPTEMBER

TIMETABLE

August	1	Midnight
August	15	11:00 P.M.
September	1	10:00 P.M.
September	15	9:00 P.M.
September	30	8.00 P.M.

(Local Mean Time)

Full Moon	August 1,	4:05 A.M., EST	
Last Quarter	August 9,	7:56 A.M., EST	
New Moon	August 16,	6:48 A.M., EST	
First Quarter	August 22,	10:02 P.M., EST	
Full Moon	August 30,	7:14 P.M., EST	

Last Quarter	September 7,	9:07 P.M., EST
New Moon	September 14,	2:13 P.M., EST
First Quarter	September 21,	9:25 A.M., EST
Full Moon	September 29,	11:47 A.M., EST

August 3-8: Venus, Mars, and Jupiter should provide interesting observations on these mornings; they are low in the eastern sky, rising about two hours before the sun, and disappearing into the dawn. Venus and Mars are in conjunction at 9:00 P.M., EST, on the 3rd; Venus and Jupiter at noon, EST, on the 7th.

August 7: Mercury is stationary in right ascension and resumes direct motion (eastward).

August 11: Mars and Jupiter, in conjunction at midnight, appear close together in the eastern sky by dawn.

August 12: The Perseid meteor shower, one of the more active showers of the year, reaches maximum in the morning sky; meteors from the shower may be seen for several days before and after this date.

August 14: The interesting display of Venus, Mars, and Jupiter in the morning sky is joined by the crescent moon.

August 16: Mercury is at greatest westerly elongation—19 degrees from the sun—and may be seen as a morning star, rising after Venus and before the sun, for several days before and after the 16th.

September 10: Mercury is at superior conjunction and enters the evening sky.

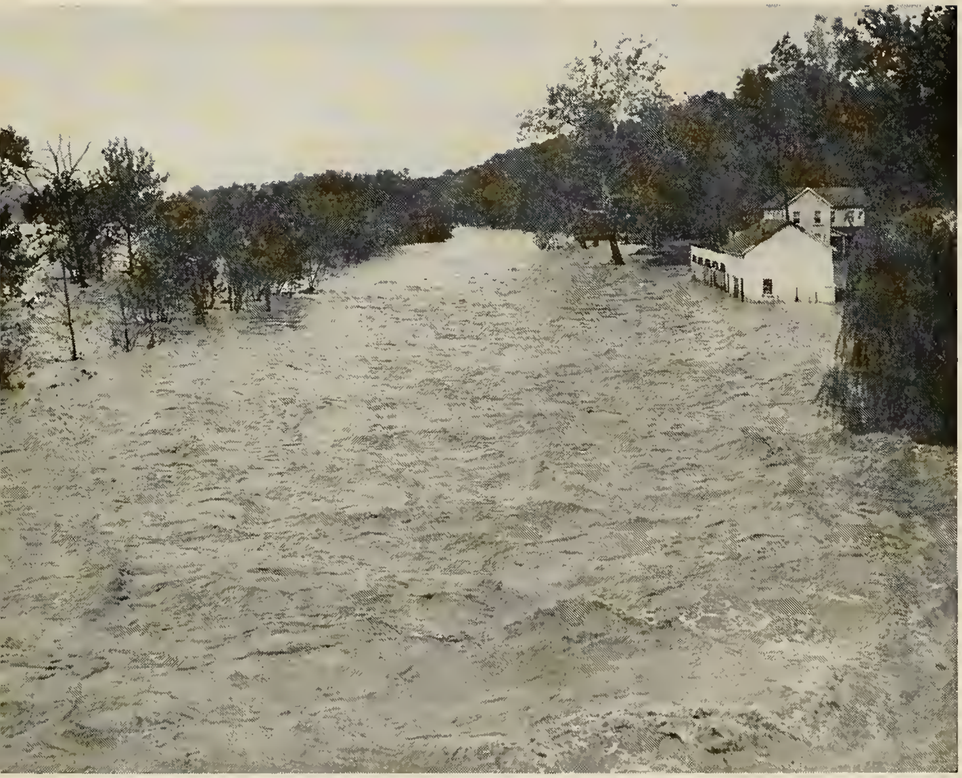
September 10-13: Venus, Mars, and Jupiter are still stretched in line, from lower left to upper right. In the early morning they are in the eastern sky; the late crescent moon passes above them on these dates. On the 10th, the moon is to the right of Jupiter; on the 11th, between Jupiter and Mars; on the 12th and 13th, between Mars and Venus. Venus, by now, is quite low in the dawn sky.

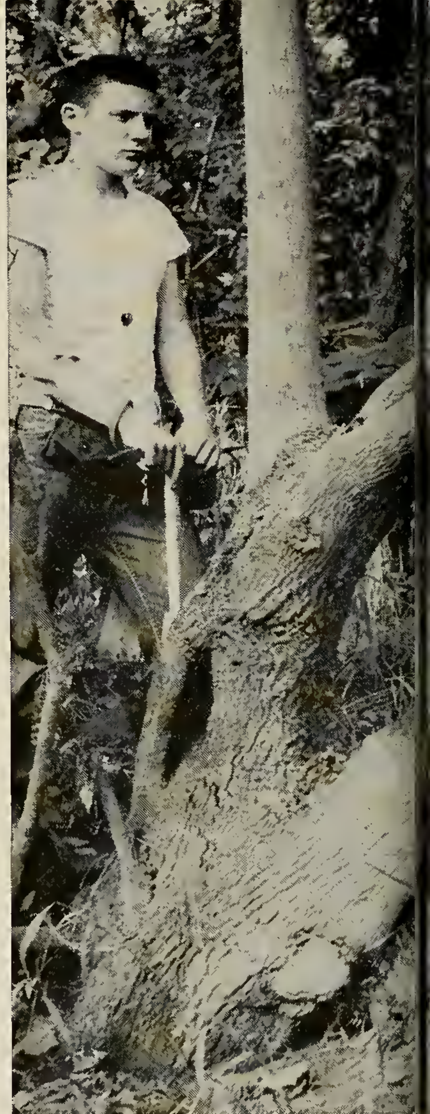
September 14: The new moon and the perigee moon occur within hours of one another today; the resulting perigee spring tides should be unusually high.

September 19: Saturn, the only planet visible in the evening sky this summer, is at opposition, and is therefore in the sky from sunset till dawn.

September 23: The sun arrives at the autumnal equinox at 6:43 A.M., EST, at which time autumn begins in the Northern Hemisphere.

September 29: Tonight's full moon is the harvest moon, the full moon nearest to the date of the autumnal equinox.





Swift torrents that inundate flood plains devastate the works of nature and man. Tree at right was flattened by a flood many years ago and grew a new trunk, which was curved by an ice jam. Other trunks sprouted anew.

Flood History Told by Tree Growth

Botanical detective work yields more knowledge of flood plains

By Robert S. and Mary D. Sigafoos

As man and his works expand over more of the face of the earth, flood plains are almost certain to be invaded to an even greater extent than today. Therefore, we shall need to understand more fully the details of the complex relationships between initiation, growth, and survival of flood-plain plants, the mechanism of erosion and deposition during floods, and the behavior of streams in flood and at low water.

It should be recognized that flood plains, which are parts of waterways, are formed in two ways: by alternate erosion and deposition along stream banks, causing the channel to migrate from one side of the valley to the other, and by erosion and deposition on the flood plain itself during floods.

In spite of this, there has been increasing encroachment on flood plains, even by large-scale housing developments. One instance is reported in a study made by the University of Chicago's Department of Geography: A river in northern Indiana flooded at least three times between 1947 and 1960, and yet the number of houses built on the flood plain increased from 140 in 1940 to 3,928 in 1960. There are thousands of similar cases. Flood plains have been invaded not only by homes but by industry, farm buildings, highways, and recreation areas.

People simply do not seem to realize—or accept the fact—that streams periodically overflow their banks to cover their flood plains. The amount of damage, in terms of mud- and water-soaked houses, inundated factories and stores, and injury and death to people and livestock, has tripled since the turn o

the century—not because floods are getting bigger, but because man is encroaching more and more.

To improve our knowledge of the history of flood plains and the behavior of their streams, the United States Geological Survey is conducting studies of flood-plain trees and shrubs. These can provide testimony about previous floods in two ways. The first is by the growth of scar tissue after abrasion of the bark by flood debris; the second is by the characteristic pattern of sprouts that grow from flood-felled or flood-decapitated trees. Such evidence has been studied in trees along swift mountain streams in the Pacific Northwest; along the Ohio River near Marietta, Ohio; beside desert rivers and washes in the arid Southwest; and along Piedmont streams from Georgia to Maryland. Flood-damaged trees are in considerable evidence along the Potomac River near Washington, D.C., and along small streams in nearby Virginia and Maryland. Observations at these scattered and various locations suggest that such damage may be found along any tree-lined stream.

The rapid flow of water and the large quantity of transported debris are the two features of flood flow most damaging to flood-plain trees. The velocities of water along the banks, over small, brush-covered islands, and at the upstream ends of larger islands are exceedingly high —up to 15 miles per hour, several times normal. The force of water alone is sufficient to bend small trees in the same way wet snow flattens shrubs and young trees; and because flooding is frequent and repeated, the bending tends to be permanent.

The water also breaks off the tops and branches of trees and, if the flood occurs in the summer, rips away leaves. Thus floodwater carries logs, branches, leaves, and other fragments from flood-plain vegetation, in addition to all kinds of debris from human habitation. During late winter and spring floods, floating ice is particularly damaging to flood-plain vegetation. Debris and ice inflict the most damage by felling, partly uprooting, or cutting off large numbers of trees.

The universal tendency of living things to heal a wound, and of certain species to replace a lost part, provides us, in the case of trees, with a dated record of the damage. Just as a starfish grows a new arm to replace one that is eaten, so a tree grows a new trunk to replace a felled one. But unlike the healing wound and the regenerating starfish, the unique characteristic of temperate-zone trees is to produce annual increments of wood. These can be identified and counted to tell us when the bark was destroyed or when the tree was felled.

A sharp blow to a tree trunk, whether made by a lawn mower, a baseball bat in the hands of a small boy, or an empty oil drum floating on high water, crushes and thus kills the living tissue between the bark and the wood. This tissue, the vascular cambium, is one of the parts of a tree that grows and is largely responsible for increase in girth. (Another cambial layer, the cork cambium, is present in tree trunks and stems. It forms cells that comprise the outer layers of the bark. The discussion here refers to the vascular cambium.) By continued cell division, the cambium forms wood on the inside and adds some of the bark outside. When the cambium around part of the trunk is killed by crushing, as happens during floods, no wood is added there immediately. Around the rest of the trunk, however, wood continues to form inside the cambium during subsequent growing seasons.

At the outset of the first growing season following injury to the bark of a tree, wood begins to grow around the margin of the wound in a manner similar to growth over a pruning scar. If the wound is small, a few inches long and less than an inch wide, it will be covered by the end of the growing season. If it is larger, several years may be required for complete healing.

The scar can be dated by taking a section through the trunk. The

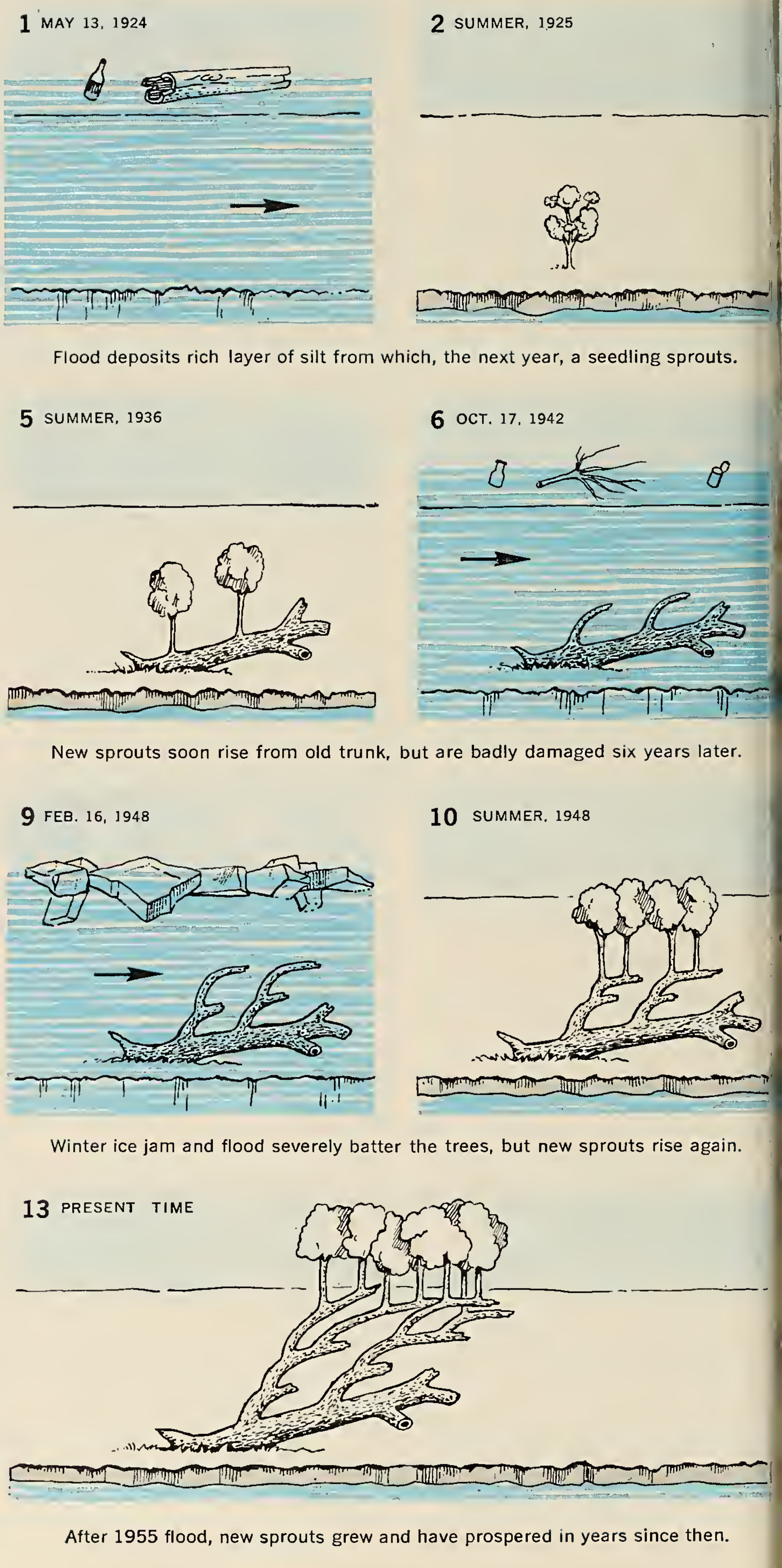
last ring formed prior to the injury is traced along its circumference to sound wood. The number of rings that lie outside the scar represent the number of growing seasons since the injury occurred. If the scar is between two rings, the flood took place sometime after one growing season and before another—generally between late August and mid-April for the latitude of Washington, D.C. Occasionally a flood occurs during a growing season, such as the one on the Potomac River on July 21, 1956. This sudden rise scarred a number of trees, and it has been preserved within the annual ring that grew in 1956.

Upright sprouts from flood-felled trees can be dated more simply than scars by taking a core from near the base of a sprout. Because the shoots started to grow at the beginning of the first growing season after the tree was felled, their age is equal to the number of growing seasons after a flood.

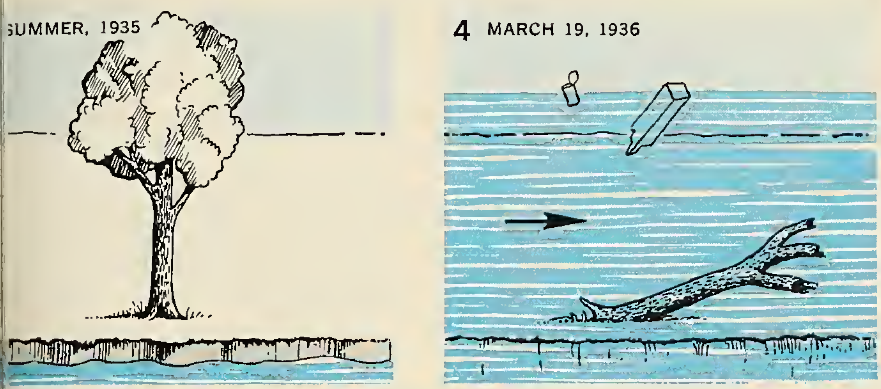
Sprouts grow from trunks of felled trees because of the complex, but not completely understood, correlations between external stimuli and growth-regulating hormones within the tree. We know by experiment that growth regulators are produced in actively growing terminal buds and move downward in a stem in concentrations that decrease with distance from the apex. We know, further, that although a high concentration of growth regulators promotes stem growth, it inhibits, in many plants, the growth of lateral buds; therefore, lateral buds near the stem tip usually remain dormant. If the terminal bud is removed from a stem and the manufacture of growth regulators is therefore brought to a halt, lateral buds and tissues within the inner bark will start to grow, forming a new stem. (In the same way, certain house plants become shrubbier if the top bud is pinched off.)

If a stem of a greenhouse plant is held in a horizontal position, growth regulators accumulate in greater concentration on the lower side than on the upper side, and are believed to move down under force of gravity. If a stem is lighted from one side only, a higher concentration of growth regulators will accumulate on the darker side. No one has reported results of such experi-

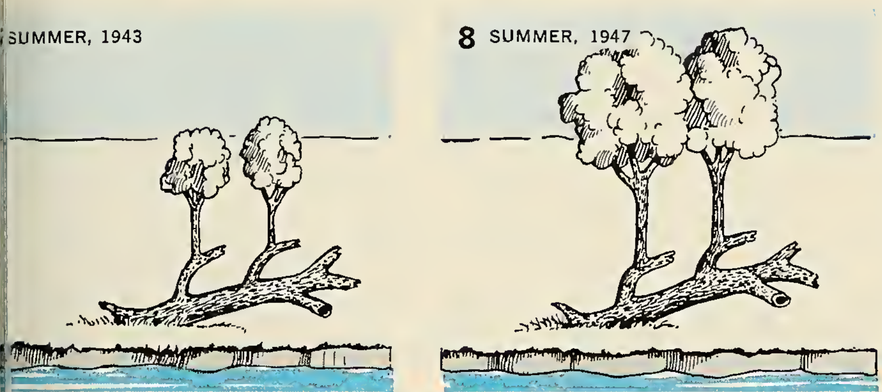
Tree vs. Floodwaters: A Schemati



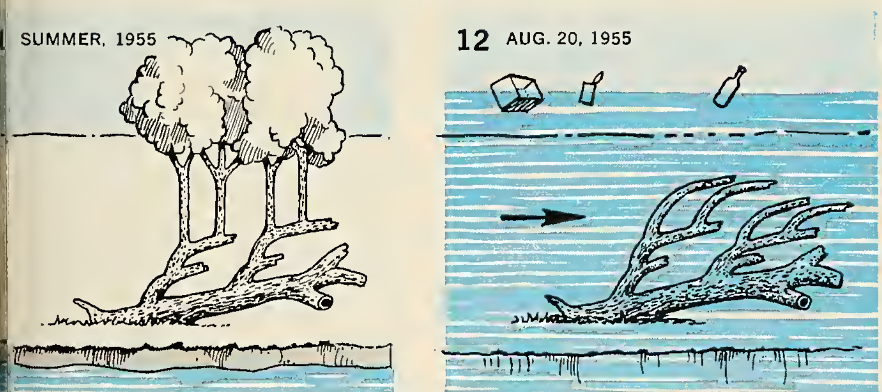
ory of Typical Flood-plain Drama



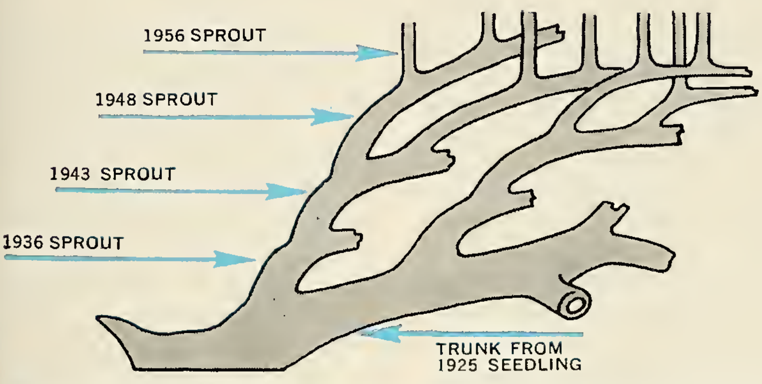
Tree grows in period of relatively low water, then is felled by a record flood.



Sprouts appear the following summer, grow vigorously during next four years.



Trees flourish for seven years, but then near-record flood does heavy damage.



Schematic interpretation shows traumatic life of a typical flood-plain tree.

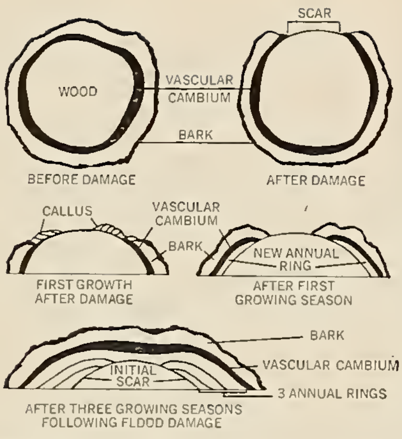
ments with mature trees, probably because they are difficult to grow in a pot on a greenhouse bench. We can only assume, then, that growth regulators in trees behave similarly to those in experimental plants.

A few observable phenomena in growth behavior of trees are best explained by the distribution and activity of these growth regulators. When growing relatively undisturbed in a forest, most hardwood or deciduous trees consist, aboveground, of a crown and one straight trunk. If the tree is cut or knocked down, or a large part of the top is severely damaged, sprouts often start to grow from the stump, from the inclined trunk, or from below the scar.

Something in the top apparently prevents the growth of sprouts from certain parts of the intact tree. When the tops are removed, the growth regulators, which are the source of inhibitors, are also removed—or a change in their concentrations takes place at lower levels—and sprouts start to grow. Bending a trunk causes the growth regulators to migrate to the lower side, thereby again removing the inhibition effect from the upper side of the trunk, and sprouts grow there.

If part of a forest is cut, such as along a highway right of way, the remaining trees initially display conspicuously bare trunks. Within a few years trunks of trees along the border of the cleared area are clothed with new branches on the lighted side. Obviously, something present in the trees when they stood in an undisturbed forest inhibited growth of branches on the evenly shaded trunks. From greenhouse studies we can infer that lower concentrations of growth regulators are present on the lighted side of the wood-border trees, and the inhibiting effect is lost.

Several conditions that favor growth of sprouts from tree trunks are created when floodwater fells trees. First, tops are severely damaged, so that the source of the inhibiting growth regulators is removed or markedly decreased. Second, trees also are bent over, and growth regulators present in the trunk become concentrated on the lower side. Third, flood felling of one or more trees opens the canopy above the felled trees and causes an



Flood-scarred trunk covers its wound, but leaves tree-ring date of injury. Vascular cambium is shown enlarged.

This scar, resulting from a flood on Difficult Run, Va., in 1957, will provide a precise historical record.

increase in light intensity on the upper side of the felled trunk, resulting in a further decrease in growth regulator concentration there. Flood-felled trees, therefore, produce sprouts at the start of the first growing season after a severe flood; with the passage of years and in the absence of further damaging floods, the sprouts grow into trees.

Only a few tree species are useful in identifying past floods. Several of these are common on flood plains, a few are uncommon, and some are quite rare, indeed. The common ones in the eastern United States are: sycamore, green ash, silver maple, box elder, cottonwood, American elm, river birch, and species of willow. The uncommon and rare ones are: yellow poplar, black walnut, red maple, swamp white oak, shingle oak, bitternut hickory, and slippery elm. The inclined trunks and upright sprouts of green ash, sycamore, American elm, river birch, and cottonwood offer the most clear-cut evidence of flood damage. These trees generally produce sprouts only during the first growing season after a flood, and the rings generally are distinct. Most of the others are too rare to have any significance, or, especially in the case of silver maple, box elder, and willow, produce sprouts each year after a flood, so that the age of a sprout is not precisely related to the time since the damage took place.

Ash tree, knocked over by one flood, was partly buried by another; then it was exposed by a third inundation.

The question is often asked: "Doesn't inundation by high water and debris kill the trees? After all, dirt was piled around some trees at a construction site down the street and they died." Evidence for a negative answer is so obvious that it often is not seen. The presence of living trees that have survived 20 floods in 32 years is sufficient proof that high water alone does not kill them. Trees are killed primarily because of lack of oxygen when the soil around the roots becomes and remains saturated, or when an added thickness of soil prevents the movement of oxygen from the air to the roots. Often it is this lack of oxygen in the soil that causes trees to die when they are partly buried. Roots of flood-plain trees, however, are usually inundated for only the few days the flood is at crest; the fine sand or loose silt that comprises most flood-plain soils permits rap subsurface drainage, once the hi water recedes.

The most important reason th trees continue to grow after a floo lies in the nature of the trees them selves. Species that grow on floo plains are different from those c uplands; and, although most tre can survive inundation of the roots for short periods of time, an some for extended periods durin the dormant season, studies sho that flood-plain species around th margins of man-made reservoi and beaver ponds can live for longe periods under these conditions tha can upland species. Some floo plain trees will survive inundatio for several months during the wir ter, and it is during the winter an spring months that floods are grea est and most frequent in the fo ested parts of the United States.

Even partial burial of trees b deposition, or erosion of so from the roots, does not kill a flood-plain trees. Upland trees in relatively undisturbed forest cha acteristically have a prominentl flared base, which consists mostl of flanged roots that taper from th trunk to the ground surface. Base of most flood-plain trees, on th other hand, do not have a flare base; rather, they resemble tele phone poles, set in the ground a though buried. The inclined trunk of many flood-felled trees protrud from the surface of the ground, an deposition has even buried th bases of many sprouts growing fro the parent trunk. Other trees sho roots and unbroken root stumps t heights of a few feet above th ground, where soil has been erode from around them.

In a hundred-yard stretch of flood plain, one can observe burie trees, exposed roots, and norma trees. This spatial variation in tre burial and root exposure tells u that flood-plain sediment is erode and deposited during any one floo and that it may be eroded or depos ited at any one place during succes sive floods. Microscopic examina tion of trunk wood that has bee buried and root wood that has bee exposed shows them to be differen in structure from normal trunks o roots; counting the rings in the ab normal wood permits dating o

either trunk burial or root exposure.

The construction of flood histories of rivers by analyzing tree damage reveals that flood plains are among the most unstable environments in temperate regions. Tree species that grow there are those that can survive frequent and violent forces. When inundated, such trees continue to live. When scarred, broken, felled, or buried, they can heal their scars or produce new trunks that permit continued life. Trees seemingly devastated by floods soon recover, and the shattered forest begins to heal. One such forest, along the Potomac near Washington, was virtually flattened by tons of ice in February, 1948, but in many places now, only eighteen years later, signs of this devastation cannot be seen from a distance. In these places, only close study in the woods reveals evidence of the ice jam.

Trees, their growth and survival, and the erosion and deposition of flood-plain sediments appear to exist in a natural equilibrium with each other. The trees affect the magnitude, nature, and precise location of erosion and deposition on a flood plain. Studies have shown that banks of treeless flood plains are unstable and rapidly erode laterally. But old trees and their dense tangle of large old roots on the vertical face of other channel banks show that those banks have been relatively stable for a period at least as long as the ages of the trees. Also it seems probable that trees in some places on flood plains aid deposition by slowing the water and allowing sediment to drop.

The ages of trees in a flood-plain forest give some testimony as to the frequency and magnitude of floods. Older trees, although damaged, survive severe floods, but seedlings are washed away or completely buried. Recently deposited or eroded soil seems necessary if seeds are to germinate; thus the presence of saplings and trees on surfaces normally frequently flooded shows that at some time in the past there was an extended period free of floods.

The zonation in trees and shrubs that one sees along a river—herbaceous plants and shrubby trees along the banks, young saplings away from the river, and larger trees on the flood plain near the adjoining hills—is the result of plant growth following floods of different magnitudes. The lower surfaces of a flood plain, supporting shrubby plants, are flooded frequently and violently. Slightly higher surfaces, supporting small trees, are flooded less often, and the force of the water is lower because the floodwaters are shallower and the trees slow them down. Finally, those larger trees that are farthest from the channel are flooded only occasionally, and forces of even the highest waters are minimal.

If man uses a flood-plain forest for recreation, the species composition will change and the forest will ultimately die because man will prevent its reproduction. Erosion and deposition at the new treeless site will be different and, perhaps, will force man to leave the flood plain. If dams or levees are built to lessen flooding and resultant damage, and if flow is increased during drought periods, the flood-plain forest will change because existing forests are in a dynamic equilibrium with the present array of floods and low flows and the attendant geologic processes. If the forest is changed or removed, erosional and depositional processes will be different. If floods are controlled, or if a higher minimum flow is maintained, the flood-plain forest will change.

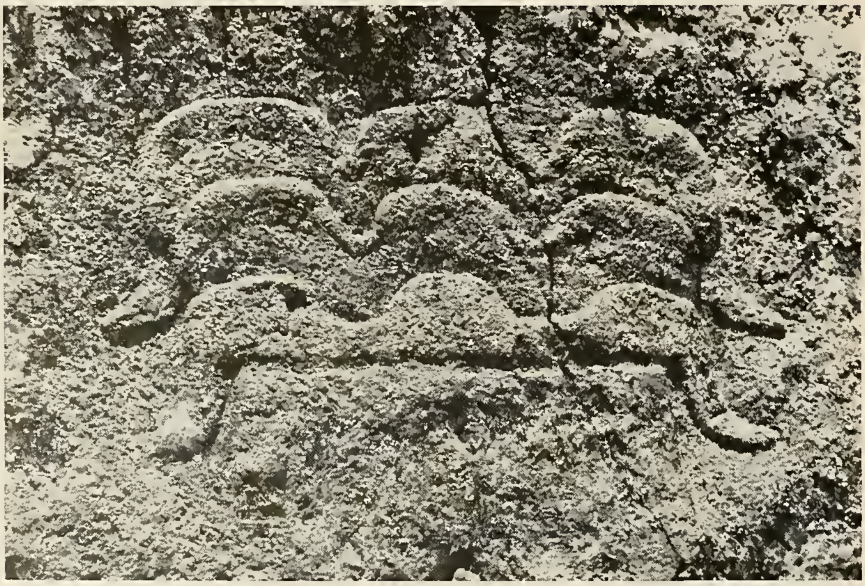
Because of the dynamic relationship between flood-plain forests and processes that form and modify the flood plain, any activity of man that changes the one will affect the other, and man will inherit an environment quite different from that with which he started.

Shrubs of willow, sycamore, and river birch on a flood-plain island would become trees in a calm environment.

Rock Carvings

RELIEF I

Drawing, above, clarifies details o 10-foot-high carving. Figure seated i midst of concentric circles is at left One of the rain cloud forms and a plan that may perhaps be corn are below



at Chalcacingo

Bas-reliefs add to knowledge of ancient Olmec culture in Mexico

By Carlo T. E. Gay

The archeological site of Chalcacingo, located about eighty miles from Mexico City, is one of the least known of the Olmec complex. Considering that the Olmec was the earliest of the high cultures of Mexico (it prospered from about 1000 B.C. to about 400 B.C.), with a highly sophisticated form of art, the importance of the site cannot be underestimated.

Several articles have been written about Chalcacingo, and a few drawings and photographs have been published, but only recently have some previously unknown, or at least unrecorded, carvings come to light. Their subject matter adds greatly to the iconography of the Olmec dossier.

The approach to the tiny village of Chalcacingo is from the Cuernavaca-Matamoros highway. A short distance from Amayuca a dirt road leads past the monastery of Montefalco, and on to the bare and dusty plaza of Chalcacingo. A forty-minute walk through cornfields completes the trip to the foot of a massive, basaltic formation called the Cerro de la Cantera, which rises nearly a thousand feet above the plain. With the adjoining Cerro Tenango and Cerro de Jantetelco, both over a thousand feet in height, the three formations are dramatized by the contrasting flatness of the surrounding plain. Seen from well out on the highway, the incongruity of their presence in an otherwise pedestrian landscape excites curiosity and admiration. The dramatic aspect of the scenery is further enhanced by a striking view of the towering, snow-capped Popocatepetl to the north. This grandeur may have influenced the choice of the site for ceremonies.

There are vestiges of a rectangular plaza, which is about 195 feet from east to west and 165 feet from north to south, and two overgrown temple mounds at the foot of the *cerro*. But the most significant feature of Chalcacingo is a group of reliefs carved into the rock on the northwestern slope of the *cerro*. To date, six major reliefs have been found. Together with a fragmented stone figure, found in a creek a few hundred feet from the *cerro*, they constitute an impressive record indicating an Olmec occupation of the site. Chalcacingo is the only pre-Classic site of the central Mexican highlands where monumental stone sculpture has so far been encountered. Distribution of the reliefs on the slope does not appear to have been regulated by any prearranged order, nor can we suggest, at this stage, any meaningful relationship between them in terms of overall symbolism.

Relief Number I, the largest of the group, is 9 feet by 10 feet 8 inches. It is located on the right side of the *cerro*, high up on the slope. Carved on a small cliff that projects from the main body of the *cerro*, it stands in a vertical position and faces east (*opposite page*). The composition is centered around a figure seated in ritualistic attitude inside a U-shaped niche, perhaps symbolizing a cave. The personage wears an elaborate headdress adorned with three sets of concentric circles and two recumbent panaches. He holds a ceremonial bar decorated with an involved S-shaped symbol. Volutes of mist or clouds roll from the mouth of the "cave."

The upper section of the relief is framed by three compound rain symbols. Each is composed of three sets of stylized cloud forms, from which falls what appears to be a curtain of rain, represented by a series of small, parallel, vertical lines.

Several other symbols are scattered at random around and above the cave—five plant forms realistically outlined; fifteen vertical "pendent dot" signs, possibly depicting drops of rain; five large symbols of concentric circles similar to the Maya glyph "Muluc"; and a composite glyphic element of crossed bands and flames within an oval cartouche. Examination of the plant forms leads one to believe they represent corn.

Raindrop signs, in groups of three, are repeated three times on the figure: twice on the headdress and once on the thigh. The emphasis on repeating certain symbols three times may be significant. According to my interpretation, this marked repetition appears to be generally associated with moon and water symbolism. When considering the various elements that compose the relief there is no doubt of their close, mutual relationship in forming one theme that seemingly expresses a ritualistic propitiation of the rain, and exalts the growth of vegetation by virtue of imitative magic.

The relief is relatively well preserved, although part of the figure's face shows evidence of intentional mutilation. A boulder partially obstructs the view of the lower left portion of the carving. In summer, the best light for studying the details occurs between 11:00 A.M. and noon.

A few yards from the relief, a small, rectangular cavity is carved in the bedrock. Now filled with earth and gravel, it can easily be overlooked. It was possibly intended for collecting rain or for receiving propitiatory water.

Relief Number II (*page 58*) is carved on a large rock at an elevation of about one hundred feet above the ancient plaza. Both this relief and Number I were first reported by the Mexican anthropologist Eulalia Guzman. Four figures, composed within a space of 5 feet 3 inches by 10 feet 3 inches, are apparently taking part in a ritual. The figure at the far right is a seated, bearded man, facing left. His arms and legs are outstretched,

RELIEF II

Photographs at left and right are of the two figures seen at far right of interpretive drawing, above. This scene may represent some kind of fertility rite or possibly an initiation or sacrifice.

wrists are tied together, and the erect phallus is clearly delineated. A horn-shaped ornament projects from the forehead of the figure. A mask is on his back, apparently a part of his regalia (*see above*). On more careful observation, however, it may be that the mask pertains to, or is part of, a dwarfed figure, backed up against the principal character. Unfortunately, the poor condition of the relief at this crucial point does not allow faithful interpretation.

Two standing figures in the center face the seated personage and appear to be dancing or moving toward him. They wear elaborate headdresses, stylized masks, capes, and belts with decorated buckles, and both brandish long-handled, paddle-shaped objects that may represent stone knives.

A fourth figure moves toward the left, receding from the others. The same ritualistic paraphernalia is associated with this figure, except that a plant form is substituted for the "knife." (Possibly this is a planting stick, symbolically adorned with leaves.) The reversed position of this figure activates the composition and helps to dramatize the scene. The dynamic rhythm of the standing figures contrasts with the formal rigidity of the bound man, and stresses the drama of the rite.

Current interpretation of the relief derives from the phallic connotation, implying a fertility theme. It has also been suggested that the seated figure may represent a prisoner marked for sacrifice. Considering the exceptional character of the theme, and that phallic symbolism is generally absent from Olmec iconography, the relief may have a more profound significance. One can only speculate as to the actual meaning and the ultimate scope of the ceremony: perhaps the scene can be interpreted as a ritualistic initiation.

This relief is no longer in its original position. At one time it slid down the slope, came to rest against another large stone, and the surface with the relief became partially hidden. In 1953, Roman Piña Chan, of the Mexico Institute of Archeology, had the top of the obstructing stone removed. The relief is comparatively shallow and fairly well preserved owing to its inward slant and the resultant overhang. Until 1953 it was further protected by the supporting mass. It faces northwest, and the best observation light for this relief occurs in the summer, after 4:00 P.M.

The third relief, 10 feet high and 8 feet long, is cut into a large boulder located about fifty yards to the left of Relief Number II. It faces north, and appears to be in its original position.

The carving portrays a full-bodied feline surmounted, on the right, by three U-shaped symbols (*bottom, opposite page*). The carving is rather shallow and follows the natural contour of the rock. Anatomical details of the animal are unusually well rendered. Although the large, erect tail and the head are somewhat out of proportion to the body, the overall plastic effect is lively and harmonious. The head, in particular, is remarkable for its naturalism and is devoid of conventional stylization, with the exception of the eye and a V-shaped sign on the ear. Faint traces of red are still visible on the animal and in other areas of the stone. The U-shaped symbols, also in shallow relief, are adapted to the undulated contour of the rock. They interlock, and extend to the boulder's top.

The particular type of feline portrayed on this relief is probably related to a "moon cult" concept, as I believe the moon deity, closely associated with water and rain principles, was represented by a feline motif or its anthropomorphic equivalent.

In that respect, the reference to Olmec jaguar types as "rain gods," which has been advanced by some students, may be correct. In Olmec iconography, however, there is a clear indication of two basic feline types, each with distinct attributes: a female usually characterized by a V-shaped symbol and no fangs and a male with fangs and no V-sign. This

lifference in types is apparent in sev-
ral anthropomorphic axes in the dis-
inct position of the hands, and by
other characteristics. There are also
examples of combined representa-
ion, generally emphasized by a more
omplex symbolism.

(Dr. Gordon Ekholm of The Amer-
can Museum of Natural History has
uggested that certain Olmec spoon-
haped objects—of jade or other
tone—might be equivalent to the an-
ient Chinese moon mirrors. These
re reported to have been exposed on
noonlit nights to collect "brilliant
vater"—probably night dew—that
vas thought to fall from the moon and was used for ceremonials.)

The relief is in fairly good condition, save for a break on top of the feline's head. Legs and paws are indistinct, the result of insufficient carving or weathering. Soil accumulation at the foot of the rock brings the ground level closer to the relief than it was at one time.

It is interesting to note that there are a few cup marks, apparently carved at random. They are similar to those encountered on Olmec monuments from La Venta and San Lorenzo. Generally indented with a smaller hollow, they have the appearance of a breast form in the negative. There is no satisfactory explanation for these cup marks, which have also been recorded from Europe and Asia of Late Paleolithic and Neolithic times. Perhaps they were devised for recording periods of time or recurring astronomical events. Because the cup marks are mammillary in shape, it is also possible they were associated with some fertility concept. It is unlikely that they were accidental gouges left as a result of tool sharpening. The Olmec monuments that bear such marks are in basalt, whereas sandstone has been the time-honored whetstone.

In addition to the cup marks, and to the left of the feline figure, there are some natural cavities that have been enlarged and reshaped by pecking with a stone implement. It is plausible to assume that they were used to accommodate offerings. There are also traces of copal recently burned as offerings at the foot of this relief and in other cavities on the *cerro*. It would be interesting to check residual deposits of copal that can be found in various niches, as it is possible that some are left from ancient times.

Relief Number IV (*page 61*) is carved on a boulder that rests against the back of Relief Number III. Like Numbers III and V, it was discovered in the summer of 1964. The scene, carved more deeply than any other of the group, is confined within an 8- by 8-foot space.

The highly dramatic theme of the

RELIEF III

*Drawing shows the somewhat weath-
ered feline figure, right, that perhaps
s associated with so-called moon cult.*

RELIEF V

Head and tongue of a highly stylized reptile was cleverly adapted to rock contours, and is some ten feet high.

composition is exalted by the dynamic, repetitive pattern of action. It portrays two human figures, each attacked by a feline. Both animals are pictured with protracted claws and open mouths. The drama is heightened by the helpless attitude of the human figures, portrayed with upraised arms, one flexed leg, and the other trailing behind.

It is apparent that a sharp definition of the attributes of both felines is established by specific symbolism pertinent to each. There is no reason to believe that the feline figuration should be connected with a "jaguar cult" per se, as has been speculated. In my opinion it is associated with separate "sun cult" and "moon cult" concepts, in each case differentiated by a proper form of symbolism. Such a clear-cut distinction between two feline types is consistent with Olmec iconography.

Far from being a secular theme, there can be no doubt of the profound, mythological significance of the composition. Each human figure appears to be overcome by a feline, possibly portraying a "sun deity" and a "moon deity." The action that takes place could be interpreted as an epic struggle between the mythical lords of heaven and the lords of the underworld. Although the account pertains to Maya mythology, it is plausible to assume that the myth may have been shared by the Olmecs.

The composition can be read in two ways: horizontally, with both felines in a rampant position, or vertically, with both semirecumbent upon the prostrated human figures. As I am uncertain of the original intention, the relief is shown in both ways on the opposite page. It is possible that the boulder shifted from its original position after the carving was executed. The sculptured surface is now leaning backward at an angle of about 25 degrees, and thus is fully exposed to the ravages of weather. It is so badly damaged that most of the details can only be seen between 1:30 and 2:00 P.M. in the summer. However, the lower right corner of the relief has partially escaped the punishment of time as a result of some protection provided by soil accumulation.

About thirty yards to the east of Relief Number IV is an isolated, rounded boulder hidden under brush. On the north side of its exposed part is a huge, stylized reptile, 5 feet 6 inches by 9 feet 11 inches, carved in shallow relief. Only the head and the front part of the body are visible, while most of the relief (Number V) is hidden under the soil, and no conclusive identification can be attempted until the carving is fully exposed (*see above*).

The sculpture is excellent. Adaptation of the relief to the rounded surface of the rock produces a remarkable illusion of movement. A large S-shaped symbol can be seen under the mouth, and a trident-shaped design is carved beneath the head. A less distinct sign, composed of crossed bands within a crescent, appears on the left side of the exposed part of the body. A long, cleft tongue protrudes from the mouth. Another curved element projects from underneath the tongue; it is not clear what it may represent. Tentatively, the reptile can be designated an earth or water monster, related to earth, water, and moon symbolism.

(After this article was written, a drawing of Relief V was published by Carmen Cook de Leonard in *Mexico en la Cultura*. The drawing indicates that the relief has been further excavated. A second and, possibly, a third S-shaped symbol is indicated under the body, while a prostrate human figure is directly in front, partly concealed by the reptile's mouth.)

Squash vine (Relief VI) was discovered in 1965 after unusually heavy rains had washed away soil that covered it.

Relief Number VI was discovered in July, 1965, about twenty feet east of Relief Number I. It represents a realistic squash vine with nine leaves, four blossoms, and two tendrils (*left, below*). It has an over-all measurement of 4 feet by 2 feet. The carving is in excellent condition, as rains have only recently washed away protective layers of soil. The most significant aspect of the relief is the blossom, which relates to similar stylized elements from Teotihuacán and Monte Albán. The close relationship between this relief and the propitiatory theme of Relief Number I is obvious.

Roman Piña Chan has shown, by ceramic analysis, that Chalcacingo was inhabited by Olmec people from the end of the Lower pre-Classic to the beginning of the Upper pre-Classic Horizon, or from about 1000 B.C. to 400 B.C. However, there is no certain way to correlate these reliefs with the site's ceramic chronology.

The same problem exists in dating Olmec monuments on the Gulf Coast. Their style and symbols indicate that most of the monumental sculpture, including the reliefs of Chalcacingo, was executed toward the end of the florescent period of the culture, or after 600 B.C. If the Olmec chronology, currently advanced, is correct, then the most productive period would span the fifth to the fourth centuries B.C.

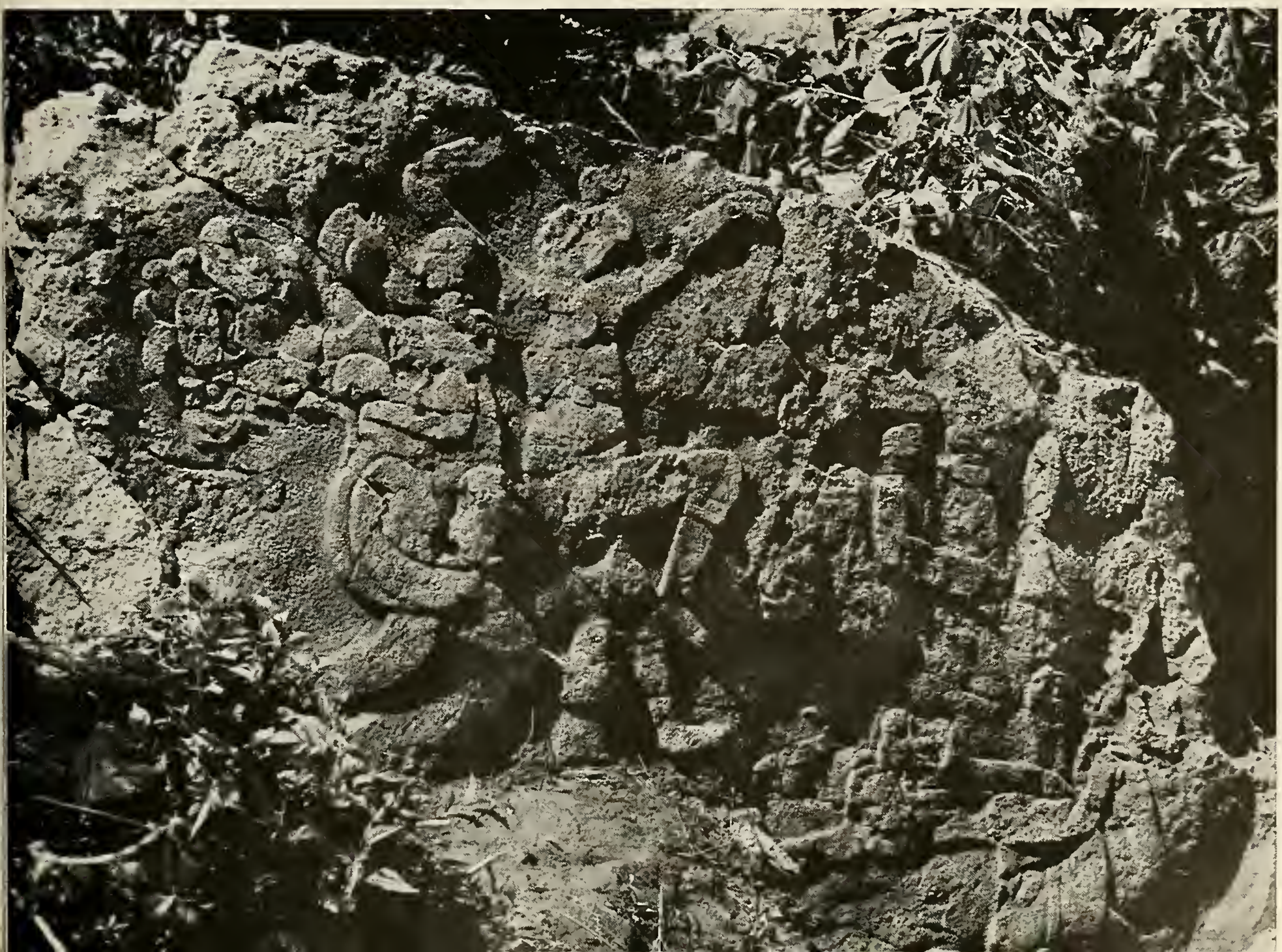
The Chalcacingo reliefs can be considered Olmec on stylistic grounds, even though they differ in subject matter from most of the Gulf Coast monuments. Points of comparison are mainly confined to style, symbols, and elements of design. Attention can be drawn to a similarity between the outline of the human figures of Relief Number IV and some of the "Danzantes" from Monte Albán. However, the superficial resemblances should not lead to the assumption that they may be contemporaneous.

The individual placement of the reliefs on the *cerro* was well conceived. Harmoniously integrated with the natural setting, they appear as decorative elements of a grandiose, architectonic composition.

Chalcacingo undoubtedly played an important role in ancient times. When the Olmec influence reached the central highlands of Mexico, the region was already more or less densely populated. The local people gradually adopted some aspects of the Olmec culture. There is no way of telling how long Chalcacingo was active as a ceremonial center. All that can be said is that the vitality of the Olmec culture ended sometime after the fourth century B.C. However, its heritage survived as an inspiration and example to other peoples. The culture's basic elements had diffused far and deep enough to lay the foundation upon which later civilizations evolved.

RELIEF IV

This highly dramatic carving, found in 1964, may depict struggle between lords of heaven and the underworld.



PORTRAIT IN SCIENCE

Darwin's "Origin" toda

By Gavin de Beer

1875

ON January 16, 1869, Charles Darwin wrote to his friend Sir Joseph Dalton Hooker: "It is only about two years since the last edition of the *Origin*, and I am fairly disgusted to find how much I have to modify and how much I ought to add." On January 22 he continued, "If I lived twenty more years and was able to work, how I should have to modify the *Origin*, and how much the views on all points will have to be modified."

At that time Darwin was seriously troubled by two lines of attack on the *Origin* that appeared to be dangerous and damaging. One was a criticism brought forward by Fleeming Jenkin, who objected that the chances of single variations (that is, mutations) becoming incorporated in a population were infinitesimally small because of the infrequency (in the then current state of knowledge) with which two similar variants could be expected to meet. He also said it was virtually certain that such variants would be swamped and oblite ated by interbreeding with the rest of t population.

Jenkin's criticism increased the dif culty under which Darwin was alrea laboring to account for a supply of vari tion sufficient for natural selection work on. Darwin admitted to Alfr Russel Wallace on January 22, 1869: " Jenkin argued . . . against single vari tions ever being perpetuated, and h convinced me." In the new (5th) editi of the *Origin* then in preparation, Da win did the best he could, which was lean more heavily on the position th variation was produced as the result then supposedly inherited—of acquir characters, of the use and disuse of d ferent portions of the anatomy, and environmental action.

The other attack that Darwin had meet was from Sir William Thomson, a terward Lord Kelvin, who claimed th the rate of cooling of the earth prov that its age could not be estimated

more than forty million years. This was extremely damaging to the theory that evolution was caused by the natural selection of random variations, and was "opportunistic" because the time available would have been insufficient to allow for the evolution of all organisms from the primordial germ, unless design and direction had been at work. This was a basic and a direct threat to Darwin's constant aim to keep the subject of evolution on a strictly scientific basis, free from metaphysical or theological concepts of providential guidance, which would, of course, have involved supernatural interference with the laws of nature.

That Darwin was shaken by this second blow is shown by a letter he wrote on January 31, 1869. "I am greatly troubled at the short duration of the world according to Sir W. Thomson for I require for my theoretical views a very long period before the Cambrian formation." But Darwin himself as a geologist had devoted prolonged attention to the length of time that must have been involved in the deposition of sedimentary rocks, and he felt justified in writing to Hooker on July 24, 1869. "I feel a conviction that the world will be found rather older than Thomson makes it."

From this standpoint Darwin has been triumphantly vindicated by the discoveries of radioactivity. Today the age of the habitable earth is estimated at some three thousand million years—ample for what Darwin called "wasteful blundering" and blind action of natural selection to have produced what it has. Darwin's fears on that score can be removed.

The Impact of Mendel

The manner in which Jenkin's attack has been parried may be introduced by quoting a passage in the *Origin* in which Darwin wrote: "The laws governing inheritance are for the most part unknown." Even the 6th edition, published in 1872, contains this passage, which, had Darwin (and everyone else) known it, was already overtaken by events. On February 8 and March 8, 1865, G. J. Mendel had delivered the famous lectures in which he laid down the foundations of the science of genetics, based on his work with generations of garden peas. Mendel's work remained unknown until 1900, when it was unearthed and confirmed, but even then the biologists of the day failed to appreciate its significance. Because the character differences then known to obey Mendel's laws were clear-cut, the opposition to Darwin's view of gradual and infinitesimal variation saw in Mendel's work a stick with which to beat Darwin.

It remained for Ronald Fisher in 1930 to show the real importance of Mendel's discovery, which was that inheritance is particulate—which means that variance is preserved instead of being

amped," as had been assumed under false notion of blending inheritance. win, of course, never knew this, but ieed not have worried on either of the es that troubled him so greatly in 9. The amount by which the *Origin* had to be modified to keep it abreast ie present state of knowledge is much than Darwin thought, from the point iew of theory, and there is much more lence now available that confirms, ex- ds, and refines its arguments.

Genetics and the Theory

ONFIRMATION of the validity and reality of the principle of natural ection comes from two sources, ge- c and paleontological. Taking the ge- c evidence first, it was shown by her that the phenotypic effects of a e are subject to control by the other es of the gene complex, and that as gene complex is reshuffled in every eration by the segregation and re- ibination of the genes, the resultant ividuals show variation of the effects he gene in question. These effects can *gradually* enhanced or diminished, ac- ding to which gene complex provides most efficient adaptation of the or- ism to its environment.

'his is why some advantageous genes e become dominant, and others have ome recessive and even suppressed. B. Ford showed about 25 years ago t a given gene in the currant moth can nade to become dominant or recessive ording to the direction of the selection rted on different lineages. In other 'ds, there is incontrovertible evidence selection at the heart of genetics. The notypic effects of a gene, clear-cut or , are themselves the result of selec- 1, and this selection gradually pro- es results—which is exactly what Dar- claimed.

Ieredity is particulate, but this does mean that evolution is discontinuous "jerky." In other words, Mendelian ietics and the chromosome mechanism vide exactly what is required to ex- in evolution by natural selection. A v edition of the *Origin* would say. refore, that the laws governing inher- ice are now known, and that heritable iation arises from the random recom- ation of segregated, previously mu- t genes.

'isher then showed by a simple dem- stration that all attempts to explain lution as a result of inner urges, ful- ment of needs, effects of use and dis- , stimuli from the environment, ortho- ietic trends, or other metaphysical icepts are doomed from the start. Such ories presuppose that there is a "fa- 'able breeze of mutations" leading to iptively directed and beneficial evolu- iary results.

That such a process has no basis in t is obvious. When a mutation first oc-

curred, environmental conditions that then existed must have been adverse to the mutation. This is why the majority of mutant genes are recessive. This demonstration is so simple that it long evaded attention. But it is inescapable that, in the words of Fisher, "Every theory of evolution which assumes, as do all the theories alternative to Natural Selection, that evolutionary changes can be explained by some hypothetical agency capable of controlling the mutations which occur, is involving a cause which demonstrably would not work even if it were known to exist." Genetics, therefore, shows that natural selection is all-powerful, while the immediate evolutionary consequences of mutation are negligible. It is only after mutant genes have been absorbed into the gene complex (if they become adaptively beneficial), segregated and recombined, and acted upon by selection that mutation plays a part.

The Zigzag of Evolution

From the paleontological side George Gaylord Simpson has shown that the rate of evolution is not correlated with variability, nor with the number of years occupied by a single generation. Furthermore, in the evolutionary history of such animals as horses, there has been no straight program at all. From the Eocene onward, the trends have zigzagged—first in the direction of many-toed browsers, then of many-toed grazers, and lastly of one-toed grazers. Those lineages that lingered and persisted too long in any of the previous trends of horse evolution paid the penalty of extinction. This, together with the demonstrable adaptation of successful lineages to changed ecological conditions, as revealed by geologic and climatological data, shows that natural selection has been the governing factor in directing evolution. By comparing related marine and terrestrial animals it can likewise be shown that it is natural selection that determines whether evolution takes place rapidly, slowly, or remains stuck, because genetic mechanism can produce either variability or stability—the former because genes can mutate, segregate, and cross over in their chromosomes; the latter because genes mutate only infrequently, they never blend, and they can be linked together in their chromosomes.

It is because natural selection is Darwin's personal contribution to science that his credit remains unblemished. It has sometimes been suggested that as he frequently spoke of "survival" as the prize of victory in selection, he was more interested in longevity than in reproductive capacity; and it has even been held that reproductive selection is "non-Darwinian." This is, however, unjustifiable, for by survival Darwin meant ability "to propagate their kind in larger

numbers than the less well adapted. David Lack's demonstration that the *optimum* number of offspring for speci survival is not equivalent to the *maximum* is relevant here.

Toward the end of his life, Darwin to his son Leonard that he expected e dence on natural selection to be availab in about fifty years. As Fisher's a Simpson's work shows, this estimate w remarkably accurate, and the eviden now available is formidable and co stantly increasing. However, only t most salient experimental results can mentioned here.

Mimicry and Melanism

In 1936, E. B. Ford showed not on that Batesian mimicry (by which o species looks or acts like another) is true adaptive phenomenon conveyi survival value but also that it has be built up by natural selection of muta genes. The proof is that where the mo els are more common than the mimics (which case predators learn quickly shun the unpalatable type), the mimet resemblance is close to perfect, and t variance of the mimics is small. On t other hand, where the models are rel tively infrequent, the mimics copy the only imperfectly and show considerab variance. When a model is less w known to predators, the survival value resembling it is small, and there is le selection pressure exerted on the mim to make it copy the model accuratel This is a case in which the close conne tion between genetics and ecology can most easily observed.

A second example is furnished by i dustrial melanism, or color variations. the middle of the nineteenth century England, a melanic mutation of the pe pered moth appeared, leading to the co stant elimination of the melanic varie by bird predators because of its co spicuousness against the natural bac ground of lichens on the trees where rested. This was a telling case of adver selection, but the mutation kept on recu ring. With the progress of industrializ tion, the countryside became increa ingly polluted by soot, and the tre became black. Now the original, gra wild peppered moth suffered from bi predators in the industrial areas.

This phenomenon is widespread. Mo than seventy species of Lepidoptera a now undergoing melanization in indu trial areas, and it has been observed spiders as well. Here, then, is a ge that, when it first mutated, was delete ous but that, as a result of utterly unpr dictable changes in the environment conditions, became advantageous a now confers survival value. In fact, t degree of dominance of the gene has i creased during the last hundred year This is one case in which evolution h been under human observation, for t

nic form has been seen to supplant ld gray form in industrial areas, and ral selection has been shown to have ted the evolution.

Sickle cells and Malaria

final example is the mutation that causes sickle-shaped red blood cells ng West African indigenes. The gene es the formation of abnormal hemo- in, the molecules of which attach selves to one another end to end, by distorting the cells and causing to look like sickles. These cells are y destroyed, and in homozygotes ividuals that have inherited only the e-cell gene) under conditions of en deficiency, this results in ane- thrombosis, and death. It is not rising that the gene is recessive. On other hand, this abnormal hemo- in prevents the entry into the red of the parasite *Plasmodium falci- m*, which is responsible for a type alaria. In regions where malaria is mic, an equilibrium is set up be- n the number of normal homozygous iduals liable to die of malaria and number of individuals homozygous he sickle gene that are liable to die hrombosis. The heterozygous indi- als (who have both normal and le genes) get the best of both worlds, they are more protected from both gers. But their genetic constitution es inevitable the production of homo- te offspring of both kinds, who will their different kinds of penalty.

West Africa, the sickle gene is ent in about 20 per cent of the pop- ion. With this percentage, four out ve homozygous sickle children die. descendants of these populations in United States, where there is no en- ic malaria, show only 9 per cent with le genes. This example shows how ral selection, opportunistically, can ert a lethal gene into one that con- survival value under certain eco- cal conditions. Furthermore, it pro- s a case of the special advantage yed by heterozygotes, and shows how percentage of a gene in a population become changed. The latter is of par- lar importance because, as a result, ution can also be defined as a sta- cal change in the gene pool of a ulation.

this way, the theory of evolution by ral selection of heritable variation stablished on an experimental basis n extent that Darwin himself would dly have imagined possible. Here, , the *Origin* can be confirmed in ry, expanded in detail, explained in hanism, and clarified. The same can aid of the fossil record, which by now provided close series of lineages—in assic ammonites, Cretaceous sea ur- s, and Tertiary horses, camels, and

elephants—and has also revealed form that are indicators of the precursors o various classes of vertebrates and of th evolutionary stages intermediate be tween them.

Advances made in comparative anat omy and embryology since Darwin's da would fill in many chapters in a hypo thetical new version of the *Origin*. Fo instance, I have found vestiges of egg tooth papillae—similar to those of som reptiles—in embryos of marsupials, de spite a hundred and twenty million year of viviparous reproduction. But refer ences in the *Origin* to the Haeckelia theory of recapitulation (in which th succession of embryonic stages in a de scendant directly represents the evolu tionary stages of its adult ancestors must be dropped in view of the muc more satisfactory principle of pedomo phosis (in which lineages evolve fro the youthful stages of their ancestors) Other advances fill out correspondin places in the *Origin:* F.C.R. Jourdain' study of mimicry in cuckoos' eggs; D Lack's analysis of the taxonomy an ecology of the Galápagos finches (th birds that played such an important pa in making an evolutionist of Darwin) and H. W. Lissmann's demonstratio that weak electric discharges from mus cles in fish can serve, on the principl of radar, to inform the animal of th proximity of other objects, thereby pro viding an explanation of the initial stage in the evolution of electric organs. Th study of ethology at the hands of K Lorenz and N. Tinbergen has reveale types of behavior that are adaptive an can be traced through related forms.

The "Origin" and New Sciences

To bring the *Origin* truly up to dat however, new chapters would have t be provided discussing branches of sc ence that were not even dreamed of i Darwin's day. Here belong serology an immunology, which provide means o measuring the chemical divergence be tween the bloods and body fluids of di ferent groups of related animals. Bio chemistry shows that the affinities o animals can be revealed by the chemica substances built into their systems. Chro mosome studies are another new field i which the minute investigation of tran locations has enabled T. Dobzhansky t unravel the genealogy of some species o the fruit fly *Drosophila.*

T. H. Huxley, that rigorous puritan o science, always maintained that the fin proof of the efficacy of natural selectio as a cause of evolution and of the origi of species (not quite synonymous would rest on whether it resulted in th production of reproductively isolate populations. K. F. Koopman has show experimentally that *Drosophila pseud obscura* and *D. persimilis* are species th can interbreed, but that even so, matin

:tween flies of the same species produce ore offspring than matings between es of different species.

Another topic that would have to be ›vered in a new *Origin* relates to pop- .ation studies that may represent, as rnst Mayr says, the most important re- :nt revolution in biological concepts. In ıe sense, Darwin himself introduced ›pulation thinking, because instead of garding a species as a "type," he ressed the variability of individuals ithin a species—"individual differences . frequently observed in the individuals the same species inhabiting the same ›nfined locality." But he slipped back to thinking of populations as types hen discussing varieties and species. It now necessary to realize that the prod- :t of evolution is a population with an lapted pattern of genetic inequality.

Sexual selection is a subject that re- ived only brief mention in the *Origin* ıd, as Julian Huxley showed, it is in :ed of revision because some of the ses in which the sexes differ in struc- re, appearance, and behavior are not tributable to sexual selection, which nefits the reproductive capabilities of dividuals of one sex, but to natural se- :tion, which benefits the whole species.

The Gene Complex

INALLY, to bring the *Origin* up to date, a new edition would contain a apter of agenda for the solution of ief outstanding problems; which are rtainly no less numerous than when e first edition appeared. Such an enda would necessarily include ade- ate theories of fitness, of sex-ratio con- ›l, of variation, and of how the effect genes is under the control of other nes in the gene complex. This last oblem will probably be worked out by e microbiologists—F. Jacob and J. onod have already found that through emically interrelated enzymes genes n collaborate to produce a controlling stem that responds to changes in condi- ›ns. Most important, of course, would the recognition that evolution must be nsidered as "dynamic" and not simply "dynastic."

r Gavin de Beer was formerly Director the Natural History Department of the itish Museum and for many years he ıs Lecturer in Zoology at Oxford and ofessor of Embryology at the Univer- y of London. He is the author of the re- nt Charles Darwin: A Scientific Biog- phy. *and numerous other books.*

ERRATUM: The editors of NATURAL STORY regret that calomel was incor- :tly designated as mercuric, rather ıan mercurous, oxide in Paul Mason lden's article, "Singular Metal from nnabar," in the June-July, 1966, issue.

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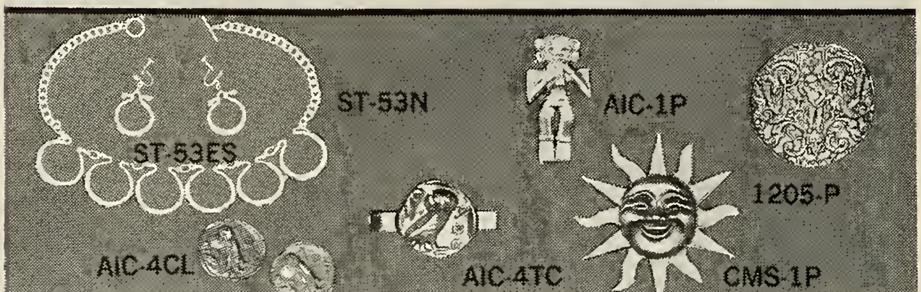

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Time-lapse photography

By William G. Smith, Jr.

[T]HE objective of time-lapse motion-picture photography is to allow us to [see], as they are taking place, activities [tha]t normally occur at too slow a rate [to b]e readily observed. By "speeding up" [su]ch processes as a flower opening or [see]ds germinating, and then projecting [the]se sequences at regular motion-pic[tur]e speed (16 frames per second), we [ar]e able to watch the flower actually un[fol]d and the seeds germinate before our [eye]s on the screen.

These and other effects are accom[pli]shed by utilizing the single-frame re[lea]se on a motion-picture camera to take [a s]eries of still photographs at predeter[mi]ned time intervals. This allows growth [or] movement of the subject to occur be[for]e each frame is exposed.

The time-lapse system of photography [ha]s proved extremely valuable in sci[en]ce, industry, and entertainment. The [bo]tanist is able to study plant behavior [un]der a variety of conditions and keep [a c]lose record of a plant's reactions to [dif]ferent kinds of light, growth regula[tor]s, or gas and chemical treatments. [Th]e mineralogist can record crystal for[ma]tion by taking time-lapse pictures [thr]ough a microscope, and the micro[bio]logist, using the same method, can [stu]dy the life cycles of minute organisms. [In] addition, time lapse is used widely in [ma]king training movies, television com[me]rcials, and animated cartoons. Years [ag]o a time-lapse system breathed life [int]o Mickey Mouse, and it would be safe [to] say that the Walt Disney empire owes [mu]ch of its success to the technique. Of [th]e numerous subjects that lend them[se]lves to time-lapse photography, how[ev]er, we will limit ourselves here to the [ph]otographing of plants.

Timing Unit

WITHIN the context of plant photography there are many systems—[m]echanical or electronic—devised for [co]ntrolling the camera shutter, the inter[va]l between exposures, the photographic [lig]hts, and the lights for plant growth, [if] they are necessary. The electronic type [of] system is to be recommended, since [th]ere will be no operational delays that [co]uld be caused by the mechanical lag [of] an instrument utilizing gears, cams, [an]d switches. An ideal unit is one that re[pe]ats the following cycle: turns off room [lig]hts, turns on photographic lights, [op]ens the shutter for a predetermined [ti]me, closes it, turns off photographic [lig]hts, turns on room lights. A unit of [th]is type consists of two timers—one to regulate the interval between exposures in seconds, minutes, or hours, and the other to activate the shutter, including the duration of the exposure (usually ½ to 2 seconds). The timer that activates the shutter can also control the room and photographic lights and can recycle itself for continuous operation.

Lighting

IN photographing plants and flowers, lamps are used both to illuminate the subject and to promote growth. For most purposes, 3200° Kelvin lamps are used at their rated voltage. They have an average life of fifty hours, and with the proper filters may be used for color film as well as black and white. (For color work, I use Kodachrome II daylight film with a Harrison B5 filter; for black and white, I use Plus X Reversal.) The use of a voltage control stabilizer is helpful, especially when filming in color, since any in-line voltage—such as might occur when a refrigerator turns on, for instance—will affect the color temperature of the lamps. Photoflood lamps are not recommended because of their short life (usually two to four hours), and while quartz lamps may be used, they give off a tremendous amount of heat. All photographic lamps, in fact, emit enough heat to cause plants to wilt and die over a long period of time; thus, as noted earlier, one of the timers should shut these lights off, both to conserve them and to protect the plants.

Plants always face the light; thus lights used to promote growth should be placed behind and above the camera so the plant will grow toward it, and in the case of a flower, as the bud opens it will face the camera lens. Space should be left around the plant to allow for growth during the period of photographing. If a closed bud, for example, fills the entire frame, it will obviously go entirely out of the field when it opens. This can be avoided by leaving room for expansion as you look at your subject through the viewfinder.

To compute the exposure, I prefer to use an incident meter rather than a reflected-light meter. Experience has proved that dark subjects, such as holly or camellia leaves, require twice the exposure that is recorded by the meter,

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Bud ready to open | *After 4 hours* | *After 8 hours* | *After 12 hours*

while light subjects, such as yellow or white roses, require one half the normal exposure. Since we are dealing primarily with time exposures, it is important that the subject material be set up where it will not be disturbed by air currents from an open window, a door opening and closing, or from people passing by.

The intervals between exposures determine the amount of movement that can be seen when the film is projected. Should the interval be too short, there will be too little movement on the screen; should it be too long, the movement will be too rapid. In general, a screen time of one minute will illustrate, at a smooth, uniform rate of movement, a growth process or a bud opening into a flower. Determining the proper interval to produce this one minute of screen time requires some knowledge of the response of the plant with which you are dealing.

For example, a rose will open from a bud to a full flower in eight hours. If the film is going to be projected at the standard 16 frames per second, then one minute of screen time equals one minute $\times$ 16 frames per second $\times$ 60 seconds per minute, or 960 frames per minute. It is thus necessary to expose 960 frames over an eight-hour period. Therefore, $960 \div 8$ equals 120 frames every hour, two frames every minute, or one frame every 30 seconds. In other words, we must expose one frame every 30 seconds for an eight-hour period in order to record a rosebud opening to full flower. The general formula, then, for arriving at exposure intervals is:

$$\text{frames per hour} = \frac{\text{desired screen time (minutes)} \times \text{viewing speed} \times 60}{\text{time of subject's response (hours)}}$$

A Range of Uses

Time-lapse photography may also be used to record the growth of fruit on trees. An interesting study can be made by following the development of a fruit from its inception as a flower. The setup is necessarily more complex than is that for photographing flowers in the studio. Equipment is needed to protect the camera from the elements; artificial li must be supplied when the day is ov cast or when night filming is requir The reader interested in this particu application of time-lapse techniques urged to read John Ott's book, *My Iv Tower*, which fully explains these a related problems.

At one time I was required to ph graph mold forming on raspberries. took three days from the time the b ries were perfectly fresh until they w completely covered with the mold. T interval between exposures was 5 m utes, or 12 frames per hour, 288 fran per day. A total of 864 frames for t three days gave a screen time of 54 s onds, and illustrated the subject ful

Some plants that can be photograph in the home are oxalis, clover, camell with large buds, and buds of Goldiloc Talisman, and Souvenir roses. Most these will respond within 8 to 16 hou The interval between exposures shou vary from 12 to 20 seconds. This w give the finished film a smooth flow action when it is projected.

The uses of time-lapse photograp are myriad. A sunset, the movement clouds, the four seasons, the motio made by a sleeping person may all recorded. Machine parts can be seen wear down, and the corrosion of me or the erosion of stone may be studied this technique. In other words, the us of time lapse are as broad and as ada able as the imagination and time of t person behind the camera equipme

This list details the photographer, arti or other source of illustrations, by pag

COVER—William M. Stephens
16-21—Richard Harrington except map, AMNH after Lyn Harrington
22-23—William K. Kirsher
24—top, Klaus Immelmann; bottom, AMNH after Donald S. Farner
25—top, AMNH after A. J. Marshall; bottom, AMNH after Donald S. Farner
26—AMNH after A. J. Marshall and D. L. Serventy
27—Eric Lindgren
35-42—Eliot Porter
44-45—William M. Stephens
46-47—The Air Almanac
49—AMNH
50—Abbie Rowe, Courtes National Park Service
51-55—U. S. Geological Survey, except diagram AMNH after U.S.G.S.
56-61—Carlo T. E. Gay except drawings, France Pratt; map, AMNH after Gay
62—The Bettmann Archi
74—William G. Smith, J

Suggested Additional Reading

THE GRAND CANAL OF CHINA

Sh'oe Pu's Diary Poem—A Record of Drifting Across the Sea. J. Meskill. Association for Asian Studies, Monographs & Papers. No. XVII. University of Arizona Press. Tucson, 1965.

Financial Administration Under the T'ang Dynasty. D. Twichett. University Press. Cambridge, 1963.

The Grand Canal of China. W. R. Carles. *Journal of the North China Branch of the Royal Asiatic Society.* Vol. 31, pages 102-115. 1896-7.

CONTROL SYSTEMS IN BIRD REPRODUCTION

The Photoperiodic Control of Reproductive Cycles in Birds. D. S. Farner. *American Scientist,* March. 1964.

The Life of Birds. J. C. Welty. W. B. Saunders Co., Philadelphia & London. 1962.

Biology and Comparative Physiology of Birds. Edited by A. J. Marshall. Academic Press, New York, 1961.

SHAKESPEARE IN THE BUSH

Return to Laughter. E. S. Bowen. Doubleday & Co., Inc., Garden City. 1964.

The Tiv of Central Nigeria. L. and P. Bohannan. International African Institute, London. 1953.

IMPROBABLE MOLLUSK

Australian Seashores. W. J. Dakin. Angus & Robertson. Sydney, 1960.

The Open Sea: The World of Plankton. A. Hardy. Houghton Mifflin. Boston, 1964.

Animals Without Backbones. R. Buchsbaum. University of Chicago Press, Chicago, 1948.

FLOOD HISTORY TOLD BY TREE GROWTH

Rivers. L. B. Leopold. *American Scientist.* December. 1962.

Botanical Evidence of Floods and Flood-plain Deposition. R. S. Sigafoos. U.S. Geological Survey Professional Paper 485-A. 1964.

Invasion and Escape on the Little Calumet. Chapter by I. A. Burton in Papers on Flood Problems. edited by G. E. White. University of Chicago Press, Chicago. 1961.

ROCK CARVINGS AT CHALCACINGO

The Jaguar's Children: Pre-Classic Central Mexico. M. D. Coe. Museum of Primitive Art, New York, 1965.

Indian Art of Mexico and Central America. M. Covarrubias. Alfred Knopf, New York, 1957.

The Hungarian boy with a passion for science... now makes precision tools for General Motors

Louis Simonffy lived in a world of order. A world of laws and theorems and formulas. First as a student of the gymnasium in Miskolc, Hungary . . . later as a mechanical engineer at Budapest . . . and finally as head of his own factory.

Suddenly this orderly world so full of promise came crashing down in the inferno that was World War II. Louis and his wife, Elizabeth, joined the vast army of displaced persons, and for six long years they drifted through the ruptured cities of Europe.

After much difficulty, the Simonffys were able to make their way to the United States, and the pieces started to come together again. First came a job as a drafting clerk, then a better one as a draftsman, and finally, in 1950, a job with General Motors. Today, Louis Simonffy is one of the ablest and most respected toolmakers in the Company.

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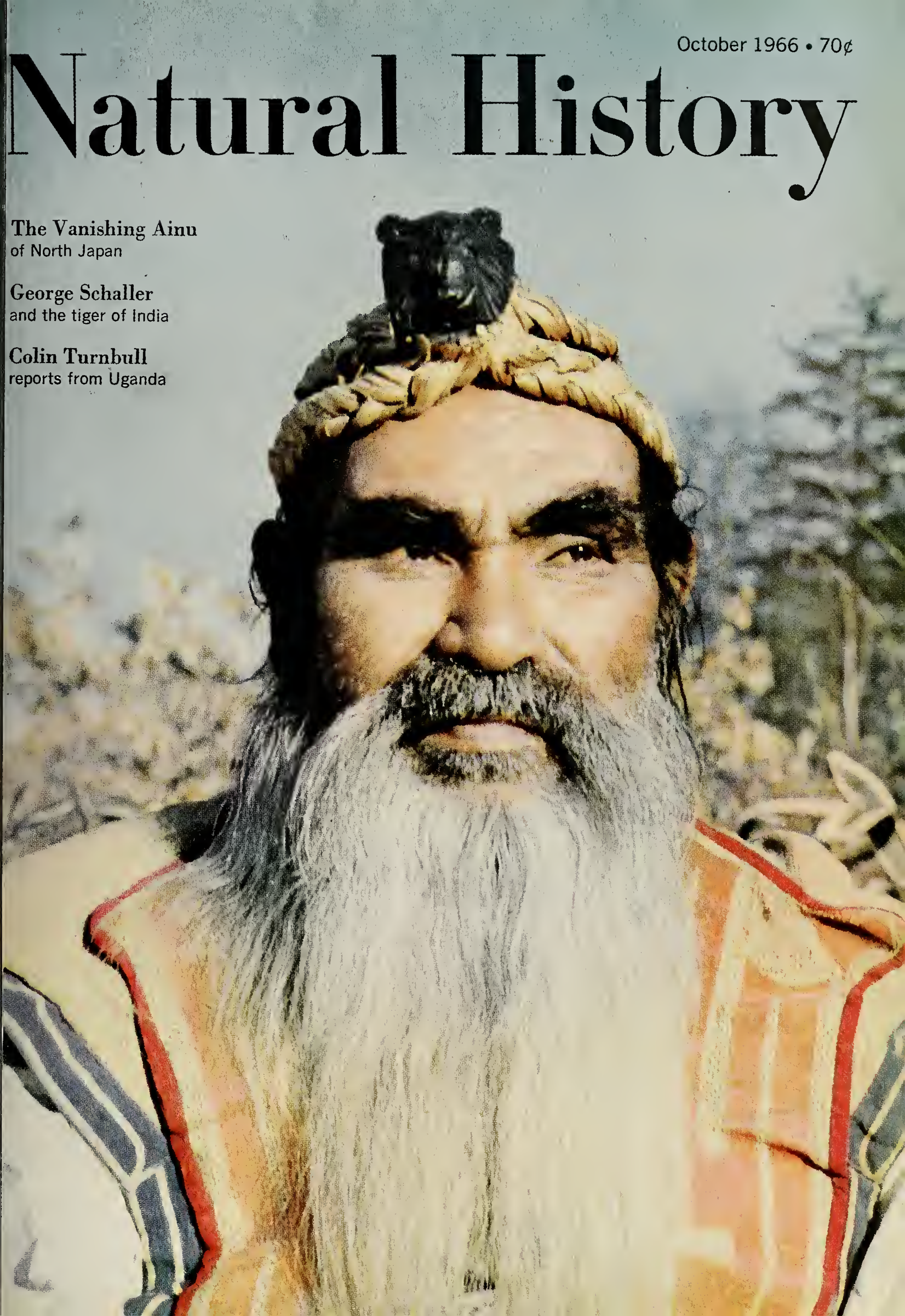
Natural History



The Vanishing Ainu
of North Japan

George Schaller
and the tiger of India

Colin Turnbull
reports from Uganda

IBM computers help schools discover budding talents

NOT long ago, most high school students took pretty much the same routine courses.

The picture has changed. Today's educators are making every effort to fit the *school* to the needs of the *individual*. IBM computers are helping make that possible in a growing number of schools.

The analysis of a child's special aptitudes now starts at an earlier age. There is more consultation with parents, more guidance in selecting subjects that will help Johnny or Mary realize their best potential in later years.

But this presents two problems:

How can teachers learn enough about each child to give him accurate guidance?

Then—how can a hundred high school classes be arranged to fit the needs of each and every student?

Courses to fit the student

This is how a 2,200-pupil high school in California solves the problem. An IBM computer can swiftly analyze each student's aptitude and achievement tests. This allows counselors to concentrate on helping students select the most beneficial subjects.

The computer prints out class schedules for each student. *Millions of calculations are done by the computer in a matter of hours.*

IBM computers also serve educators in analyzing the factors which are keeping students from achieving better grades.

Saves $3 million on school costs

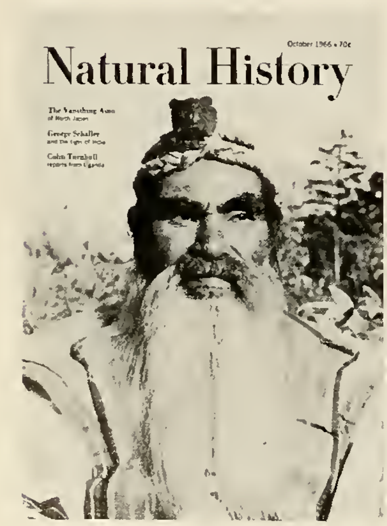
IBM computers also help plan more efficient schools at lower cost. At one Midwest city, the computer was given specifications for a proposed junior college—the classrooms and labs needed for its student body and faculty. The computer then printed out a plan for an efficient campus that cost three million dollars less than the original estimate.

"Meets our main objective"

A leading educator said, "IBM computers have lifted loads of paper work from our teaching staff, allowing them more time to help the individual student. But, best of all, computers help us meet our main objective of helping each student find and develop his special talents."

IBM®

IBM computers help counselors to find students' special aptitudes. These high school sophomores are shown measuring the rate at which plants absorb radioactive water.



Natural History

Incorporating Nature Magazine

THE JOURNAL OF THE AMERICAN MUSEUM OF NATURAL HISTORY

Vol. LXXV | OCTOBER 1966 | No. 8

ARTICLES

DEPARTMENTS

COVER: One of only a few score pureblood Ainu surviving today, 73-year-old Kichiro Iga lives in the village of Kawayu on the island of Hokkaido, Japan. He is dressed in ceremonial robes and headdress. Cloth for the long-sleeved, kimono-type gown was woven from thread made by twisting elm fibers. On pages 16 to 25, Professor Shin'ichiro Takakura describes the mystery of the origin of the Ainu, a hirsute people appearing somewhat more Caucasian than Mongol. He tells of the loss, almost entirely within the past one hundred years, of their distinctive culture as a result of their rapid assimilation by the Japanese.

The American Museum is open to the public without charge every day during the year. Your support, through membership and contributions, helps make this possible. The Museum is equally in need of support for all of its work in the fields of research, education, and exhibition.

Publication Office: The American Museum of Natural History, Central Park West at 79th Street, New York, N. Y. 10024. Published monthly, October through May: bimonthly June to September. Subscription: $7.00 a year. In Canada, and all other countries: $7.50 a year. Single copies $.70. Second class postage paid at New York, N. Y., and at additional offices. Unsolicited manuscripts and illustrations submitted to the editorial office will be handled with care, but we cannot assume responsibility for their safety. The opinions expressed by authors are their own and do not necessarily reflect the policy of The American Museum. NATURAL HISTORY is indexed in *Reader's Guide to Periodical Literature*.

Now the magic of the theatre comes to your home

Shown above: Julie Harris, Claire Bloom, Laurence Olivier, Judith Anderson, John Gielgud and Ralph Richardson as they appear in Society productions.

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Through a unique new theatre club, you can enjoy thrilling performances of the world's greatest plays in the comfort of your own living room. Start with Tennessee Williams' haunting drama The Glass Menagerie for only $1 (catalogue price: $12.90)

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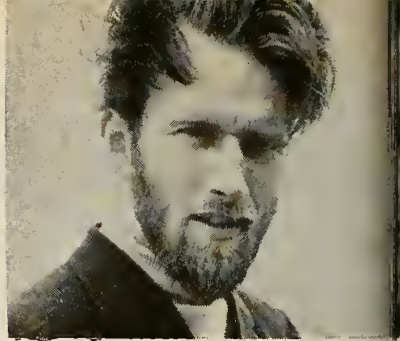

Mr. Turnbull

ABOU

Dr. Smith

Just before press time, a report f
Africa arrived, sent from Uganda
COLIN M. TURNBULL, Associate Cur
of African Ethnology at The Amer.
Museum of Natural History. With it,
covering letter, came the suggestion
the report might be found by some t
an unduly candid account of the "fra
state of mind in the field." However,
Mr. Turnbull and the editors felt the
value—even ethnographic value—in
port that explores a dynamic interac
between an anthropologist and his
this case, disturbing subject. His re
entitled "A People Apart," docum
an instance of the clash of cultures.
Turnbull's other writings include
Forest People and *Wayward Servant*.

For DR. SHIN'ICHIRO TAKAKURA
Ainu people of Japan have been sub
of personal, as well as scholarly, inte
Although not of Ainu descent, he
born in their midst in the Tokach
gion, the southeastern plain of
kaido, which was then, in 1902, a fro
in the sense of the American West.
he entered Hokkaido University's Sc
of Agriculture and earned the docto
the *Nogaku Hakushi*, for his dissert
on the history of Ainu policies. Dr. T
kura recently retired from the De
ment of Agricultural Economic
Hokkaido University. He is, how
continuing his research at that u
sity's School of Literature.

DAVID S. HARDY waited a long tin
fore he could work professionally
what had been his chief avocation, s
lent plants, particularly those in
nous to South Africa: the stap



Dr. Takakura *Mr. Hardy* *Dr. Schaller*

HE AUTHORS



Mr. McCoy *Mrs. Millar* *Dr. Renner*

ion flowers), the aloes, and the ɔs commonly known as flowering s. On leaving high school in Cape ı, he accepted a civil service post in erinary research laboratory. After years of this work, however, he ht and was granted a transfer to the ɔnal Herbarium in Pretoria, where now a Botanical Technician in the ırtment of Agriculture Technical ices. Much to his delight, his new often takes him afield in search of arium specimens.

pecially written for NATURAL HIS-, DR. GEORGE B. SCHALLER's article igers is based on material in his coming book, *The Deer and the Ti- A Study of Wildlife in India,* to be ished shortly by The University of ago Press. This work on predator– relations was supported by the Na- ıl Institutes of Health through a t made to the Johns Hopkins Uni- ity Center for Medical Research and ning, Baltimore and Calcutta. Dr. ıller is now a Research Associate in Institute of Animal Behavior of the York Zoological Society and Rocke- r University. He has recently begun ıg-term study of the lion and its prey he Serengeti Plains in Tanzania.

R. C. LAVETT SMITH, who wrote the ros Reef article, is Assistant Curator ıe Department of Ichthyology at The rican Museum. He is also Codirec- of the Museum's Bahama Survey, a ram of concerted biological investi- ɔn of the Bahama Islands. One of Dr. th's personal Survey projects is a y of the ecology of fish communities.

EDWARD C. MCCOY, the photographer whose underwater shots illustrate the article, is an ensign in the U.S. Navy serving on board the U.S.S. *Sylvania,* which is now cruising Mediterranean waters. He is a graduate of the University of Miami and expects, after his service in the Navy, to do photographic essay work on the flora and fauna of the Pacific. His photographs of the Andros Reef were taken with a Rolleiflex twin lens camera encased in a specially built, cast-aluminum housing. An attached flash arm used standard number 25 flash bulbs.

LYNN MILLAR wrote and took the photographs for the article on the Seychelles Islands. She is the wife of a U.S. Foreign Service officer presently stationed at the American embassy in Dar es Salaam, Tanzania. Mrs. Millar is a Vassar graduate and a former news photographer for the *Washington Post* (D.C.). In addition to preparing photographic exhibits on Berlin, she has published several magazine articles on various aspects of life in India and Africa.

DR. MAX RENNER, author of "Time and Space in the Life of the Bee," is a lecturer and Senior Scientific Assistant at the University of Munich's Zoological Institute. His research centers on animal orientation and sense physiology, particularly in honeybees. A former student of Karl von Frisch, Dr. Renner's extracurricular interests include classic and contemporary literature, the history of biology, and photography. His article was translated from the German by Dr. Helmut Adler, Research Fellow in Animal Behavior at The American Museum.

Report from Africa:

A PEOPLE APART

by Colin M. Turnbull

NEAR PIRRE, UGANDA

THIS is written from inside a small, circular mud hut, dark—despite the brilliant sunshine outside—because the door has to be closed to ward off unwelcome visitors who are not deterred even by the eight-foot stockade around the house. There are no windows, but some light and air come in through the eaves, where the thatched roof clears the wall by four or five inches. The floor slopes at a ridiculous angle, and the furniture, a bed and two tables made of saplings lashed together with vine, only seems to add to the discomfort. Outside, however, life is even less comfortable, for there is no shelter from the blazing heat, any more than there is from the freezing rain that is likely to follow in an hour or two, blown down the valley by gale force winds. Distances between villages may not be enormous, but because of the rugged mountain terrain, with ravines a thousand feet deep to be negotiated, it may take a good eight-hour trek to cover as little as ten miles or less, as measured by a straight ruler on a flat map. And even where the land is level for a few hundred yards it is covered with sharp thorns that tear at the arms and legs and, when broken off, penetrate the stoutest soles. Yet, except in moments of temporary despair, it all seems worth while, for although it is like taking blood from the proverbial stone, there is much knowledge to be had from such conditions. The field worker unlucky or unwise enough to have made such a choice is bound to learn not only about the people he is studying but also about himself.

Perhaps even more important, when conditions are as extreme as they are here, in the very northeasternmost corner of Uganda, they make the anthropologist think very carefully about the validity of his results. Here the human environment is just as difficult to cope with as the geographical, and if it is hard for the field worker to accurately and conscientiously survey mountain farmland that frequently slopes at an angle of over seventy degrees, it is even harder for him to maintain his equilibrium while attempting to relate to a people who, while not wishing him any harm, nonetheless wish to strip him of everything he possesses, whether they can conceive of any use for it or not. Nor is it easy to feel at home with a people who regard each other in a similarly covetous light, and who consequently surround themselves with a barrage of deception and ring their homes with tight, virtually impenetrable stockades and thorn fences, dividing brothers from each other and parents from children. While it is true that the anthropologist is no more separated from such people than they are from each other, it is questionable whether he can in a brief year or two ever truly penetrate such formidable defenses and understand just how such a society can survive. Even the hardest head, professing the greatest scientific detachment, can surely not fail to judge harshly when a plump, hearty youth is seen beating

a starving, tiny, demented girl fo the fun of stealing from her the onl food she has seen for a day or two; o when an adult audience roars wit laughter as one of their number sneak food from the bowl of a blind elder a he is eating; or when parents abando children (or vice versa) to die, not be cause they could not be fed, but becaus it would simply take too much trouble— any amount of trouble being too muc The field worker may eventually lear to penetrate the stockades by wrigglin through the low doorway on his ston ach or on his side, having first a nounced his intention so as to avoid b ing attacked, but can he ever penetrate mentality that looks on with mild amus ment as food and water that could sav a life are stolen from the dying?

Anthropologists all too often clai to have understood and explained prim tive societies *in toto*, as though the was no more to be said on the matte They present a clearly defined syste that would work admirably, like a m chanical model; but also like a mecha ical model, it would get nowher Perhaps we are all too much concerne with explanation, and too little co cerned with understanding. A socie like this one, however, defies any e planation, at least for a very long time none of the standard social systems, which the theoreticians are so fond a so proud, fit even in part; the fie worker is driven, rather like the peop he is studying, simply to concentrate surviving, in the hope that understan ing will come, even if system does n

Anthropology, the study of man, divided into several different areas these days of specialization. It is a stu of man as a biological entity, as a histo cal entity, and as a social entity. O of the pities of such specialization that there is an inevitable tendency separation, as though man were capab of being rent into discrete parts a still exist. Even within a division, su as social anthropology, there are sub

For the better part of a year and a half, Colin M. Turnbull, Associate Curator of African Ethnology at The American Museum of Natural History, has been studying an unusual and little-known tribe who live on a high, rugged escarpment on the Uganda-Kenya border. This is his report from the field.

visions. There are those who seek to answer very specific theoretical problems, and who select a society for study because it illustrates those problems. Others answer a call to solve more empirical problems. such as those posed by the rapid social changes taking place in formerly undeveloped areas. Others, like myself, prefer to undertake a more general quest without any specific expectation except the broadening of our knowledge of human society. We choose a society to study because, in the first place, it is unknown and promises fresh data, and perhaps also because it is generally in line with our own interests, likes, or dislikes.

I like forests, and I am interested in hunters and gatherers, so when casting about for somewhere to go for further research I first chose the Andaman Islands, where the Onge still live (on the Little Andaman) in depleted numbers, but still relatively untouched by civilization. The study would have provided invaluable data for comparison with other hunters and gatherers in similarly forested environments; it would have been of particular interest to me because of my previous work among the Pygmy hunters of the Congo. But it was not to be; for various reasons the Indian government refused permission, and with little time left I had to make an alternative choice.

Just then Elizabeth Marshall, author of *The Harmless People*, returned from northern Uganda where she had been gathering material on the Dodos, one of the great Karimojong peoples. She suggested that since I was so interested in hunters, why not visit the Teuso, who allegedly lived high up in the mountains above the Uganda/Kenya escarpment, and who had first been reported in a very brief note in an academic journal in 1931. She painted a delightful picture of a warm and friendly people, full of fun, whom she had met during their occasional visits to the administrative center of Kaabong, a tiny outpost near the point where Uganda, Kenya, and Sudan all meet in an incredible conglomeration of jagged mountains, arid deserts, and lush, gemlike, and isolated valleys. I reluctantly gave up the idea of a cool forest, and prepared for the hills.

"My third mistake, and the greatest, was to assume that these gentle, smiling, friendly looking people . . . were as gentle and as amicable as they appeared."

Here again anthropologists differ widely in the kinds of preparations they make. I think all of us read up on whatever literature is available, but in this case it amounted to no more than a few pages. Some then prepare as for any other kind of expedition, purchasing camping equipment and such supplies as cannot be bought locally in the field. Medical supplies have to be carefully assembled, and the necessary innoculations taken. It is all very matter of fact, and when the anthropologist arrives in the field all he has to do is to set up his tent, or tents, assemble all his camping equipment and stores, and then proceed to work much as if he were still in his office, but with an abundant supply of raw material all around. Such an anthropologist deliberately establishes himself outside the community he is studying; some even stay in nearby resthouses or hotels if a town is not too far away. They visit the "field" daily, and pursue a diligent course of study, which they carefully plot as they go along, step by step. They are free from local involvement, emotional or otherwise, and can more easily preserve the intellectual detachment we all aim for. They necessarily miss a great deal by not living in the village with the people, but they claim that their vision, if limited, is clearer by being more objective.

There is no right or wrong way; it depends a great deal on the purpose, as well as the nature, of each individual case, and on the personality of the field worker. I prefer to enter a society as completely as possible, for although it becomes impossible to maintain as high a degree of objectivity at the time, one gathers much more material and in much more intimate detail, and this can be treated as objectively as you like when, once out of the field, the material is being analyzed. Of course, it is then too late to fill in any gaps that might result from being too immersed in the subject itself, but on the whole I find the rewards are richer. My previous two major experiences of this kind, in India and in the Congo, had both been immensely fruitful and, at the same time, immensely pleasurable. Minor physical discomforts were quickly obliterated by the constant excitement of discovery and the pleasure of companionship with people who welcomed my desire to learn their ways and were anxious that I understand them well. I saw no reason to think it could be otherwise with the Teuso. That was my first mistake.

The second mistake I made was to as-

sume that the Teuso were hunters until I saw their intensive cultivation, and then to assume that they were farmers. My third mistake, and the greatest, was to assume that these gentle, smiling, friendly looking people who extended such a warm welcome were as gentle and as amicable as they appeared. It took a long time—almost a year—to convince me otherwise.

I arrived at Kaabong at a time when drought was beginning to result in famine. The famine struck the Turkana in Kenya even more heavily, and they were beginning to intensify their raids on the Dodos in Uganda, so that for two weeks the local administration was reluctant to allow me into the danger area. During these two weeks I stayed at Kaabong and met some of the Teuso who filtered down through the mountains in search of food. Two Teuso boys had, during a previous famine, decided to go to the mission school, where they were well fed, as well as well taught. They spoke their own language and Karimojong, which is the lingua franca in this area, and they also knew some English and Swahili. From them, I was able to work up a fairly respectable vocabulary and determine the basic grammatical pattern. I found it relatively easy on paper, but enormously difficult in practice, for the sounds were utterly unlike anything I had ever attempted to make, or had even heard, in a linguistic context. In the course of learning to splutter appropriately, I learned that "Teuso" is only a name applied by the Dodos, and that the tribal name is Ik. Their language is utterly unknown to any of the neighboring tribes, with whom they communicate only in Karimojong. It was unlike any African language known to me, and did not seem to conform to the Sudanic classification it had tentatively been accorded. Perhaps it was the somewhat Bushmanoid appearance of the people that tempted me to see a possible linguistic connection in that direction but from the outset it was quite plair that the Ik were a people apart from al others in the region, linguistically, physically, and culturally.

As soon as permission came through I spent a month visiting all the different villages, traveling by jeep as far a practicable, then simply walking o climbing. The effects of the drought ha been disastrous. The fields, which ha been planted with such evident care ar labor, had received just enough rain the beginning of the season to bring o the young shoots. Then the sun had con to stay in the cloudless sky, burni everything. It burned the crops of t Ik; it also burned the grass that t Dodos needed for their cattle, and dried up the few water sources that bo needed to survive. The outlook was ba and I was impressed by the cheerfulne with which the Ik accepted the almo certain disaster. Even after the gra that should have been reserved for ne year's sowing had been consumed a when there was no longer any chance f rain coming in time to yield a harve, the Ik, for a reason I could not then

They "surround themselves with a barrage of deception and ring their homes with tight, virtually impenetrable stockades and thorn fences . . . ."

derstand, remained optimistic. All, that is, except a few old people who were barely strong enough to crawl from their huts to talk. They simply said that they would die, since there was nobody to bring them food, and they were too weak to hunt or gather the wild vegetables that were still about. When I asked if they did not have children to help them, they just laughed—a laugh I quite misunderstood. It was a hollow, hopeless sort of sound that I have heard all too often since, and those who have made it have, as they predicted, mostly died. They did indeed have children, who remained obstinately optimistic and singularly well fed while the skin hung off their parents in long, wrinkled folds, leaving bones to stick out as though in angry protest.

The optimism of the youths, whose plumpness was perhaps comparative but who nonetheless could at least walk upright instead of having to drag themselves along the ground, lay in their knowledge that the drought, two thousand feet down below the escarpment, was even more disastrous for the Turkana. The Turkana, like all Karimojong, live by cattle. They drink the blood and milk of the cows and occasionally eat the flesh of their goats and sheep. The drought became so severe that raids on the Dodos were no longer sufficient remedy, for there simply was no food or water for the vast herds they possessed. Their only recourse, as the Ik well knew, was to climb up the escarpment, invade Uganda, and graze their cattle there.

By then I had decided to make my headquarters near the frontier police post of Pirre, on the side of Mount Morungole, overlooking the Kidepo National Park. There was a cluster of seven Ik villages there, and I had already seen a good deal of the remaining six villages to the east, along the top of the escarpment itself. It was, of course, into Kidepo that the greatest Turkana invasion came, with many thousands of cattle. They drove the Dodos from Pirre; this tiny police post, housed in about a dozen huts, was completely incapable of doing anything against such numbers. The track to Kaabong was barely passable even by jeep, the radio equipment broke down, and the local administration was in a quandary as to what to do, short of calling in the army and creating an international incident.

So the Turkana took possession of Pirre, and I confess that I found them a welcome change, wild and aggressive though they were. They said they had no wish to fight, but only wanted to graze their cattle. They promised they would do no harm if left alone, and although they have probably one of the most unsavory reputations in the whole of Africa, I never doubted their word for an instant, nor did they go back on it even under provocation.

The Ik now displayed their talent for ›urvival. They busied themselves mak-ng spears for the Turkana, who had re-;ently been persuaded to surrender heirs as a peace gesture toward the Dodos. For this service they bled the Tur-cana much as the Turkana bleed their :attle, but with rather less consideration. The Ik began to grow fat again. They hen persuaded the Turkana that the Dodos were a menace and began insti-gating raids between the two, acting irst as spies for one side, then for the ›ther, drawing pay in the edible form of :attle from both sides. Ik villages that ıad never possessed a single goat be-gan to build *bomas* and to fill them with iterally hundreds of cattle. They ate hese as rapidly as possible, for they ‹new very well that any attempt to keep hem would only result in their being tolen back. The youths continued to put ›n weight, but the old people remained ıs thin and emaciated as ever.

The Turkana were eventually forced ›ut by the army, which left the Ik with ›nly the Dodos to prey on, and the Dodos hemselves were near starvation. The ›ld people among the Ik began to die, ınd children, and even some of the ·ouths. The selfishness shown over food vas terrible to see, but seemed almost ex-·usable under the circumstances. I my-elf was driven into hiding every time I vanted to eat, although I had barely ·nough for myself, since fresh supplies vere unobtainable and I had given what could to the old. Yet I was wary of ·ven biting into a dry biscuit in case omeone should hear the crunching and :ome and demand a share. When people ‹new anyone was eating, myself included, hey came and sat around in a silent, ıungry circle, knowing that nothing vould be left for them, but hoping. I vould have excused them anything dur-ng those days, just as I hoped they vould excuse me.

THE new year came, and with it the first rains in over twelve months. Vork in the fields was slow to begin vith, for few people had the strength. 3ut the rains brought up edible grasses, vild berries and fruits appeared, and ;radually the danger of full-scale starva-ion receded. Now the crops are well on he way to bringing in a fine harvest, and he wild foods grow in abundance all ›round. What has not grown, however, s any evidence that the Ik—even in such elatively good times—have any consider-ıtion for one another. Food is still the lominant thought; food getting the dom-nant activity. And, still, it is each indi-idual for himself. At dawn, children ›ock out in a large, single, unruly band nd scavenge the surrounding country-ide for anything that might have come ıp during the night. The three- to seven-r eight-year olds are too young to risk

going any great distance, where they would stand a better chance. Their older brothers and sisters, having beaten the younger ones to get what they had not yet eaten, go farther out on hunting parties of their own. If caught by their parents, they, in turn, will be beaten and robbed. The adults steal from each other and angrily denounce each other, kinship affording not the slightest bond of mutual respect. A mother will leave her children, even one barely weaned, in care of a father while she goes off to gather for herself, sometimes staying away for a week. Meanwhile the father will go off and leave the children in care of grandparents too old to fend for themselves. To get water, for instance, may well involve a walk of three miles and a descent (and climb, in the reverse direction) of a thousand almost sheer feet. When someone dies, there is no wailing or mourning, merely a great deal of grumbling by the next of kin because of the obligation it places on them to provide ritual purification involving a feast for relatives.

I saw one father hurriedly bury his ten-year-old son by the door of his hut, so as to avoid the expense. The night before, he had beaten his wife to stop her crying when the child died, for by so doing she announced the fact he wished to conceal. All day he sat on a rock and grumbled at his son for dying, at his wife for crying, and at his relatives for demanding a proper burial, including the appropriate feast, to which they would have to be invited. It is, perhaps, at least comforting that the mother cried, but it is the only time I have heard it.

The old people tell stories of better times when, not so long ago, Kidepo Park was theirs to hunt in as they pleased; when the boundaries of the three countries were not subject to armed patrols; and when they could roam at will in search of food and game, instead of being restricted and compressed as they are now. They wonder why the animals in the Park are protected and allowed to live and flourish while they must die. They wonder why their children have abandoned them, for they remember how brothers would all join together, in the old days, to look after their parents. But even the old people, now, have only one concept of good. It is nothing that can be applied to an action, or to a relationship between one human and another; it is only a condition, clearly defined as "having a full stomach." This is the basis of their life, of their law, of their morality. It is a goal that justifies any action except killing, for the Ik never kill. Their legend of origin tells how God gave spears to the Karimojong, together with cattle, so that they have wealth but also the means to bring death. God gave the Ik the digging stick, and told them not to kill. They don't, they just let each other die. Meanwhile they live a life de-void of affection. A woman's attitude t childbirth is that it is a nuisance, anothe mouth to feed for two or three years. A mother may be amused by her baby but that is about as close as she seem to get to affection for it. When it is sic or hungry it is simply slapped an cursed as an annoyance. The most equa ble kind of interpersonal relationshi regardless of kinship, is that of mutua economic reliance, but this is temporar at best and inevitably ends in cheatin and mutual recrimination.

The tightly stockaded internal div sions, which turn every village int a series of independent fortresses—eac occupied by a nuclear family, each wit its own single, sometimes booby-trappe private entrance—is sufficient evidenc of the state of degeneration into whic this society has been thrown by events cannot understand. Youths have no co cept of what their grandparents are tal ing about when the old folk grumb about the young deserting the old. On wanting some food I was about to gi to an old, old woman, said "Why give to her? She is going to die anyway When I said it might make her a litt happier meanwhile, he became angry the waste, for such he considered it.

The economic noose that has be drawn around its neck may be enoug to explain the condition into which society has fallen, although even of th I am not yet convinced. It is difficult understand how, even under such ci cumstances, a human society can exi and survive as successfully as this o does, devoid of nearly all those qualiti that we consider raise us above the le of animals. And however well one m be able to explain the society as it fun tions at present, is that explanation val without any understanding of the peop themselves? For even simply as peopl I still cannot understand the Ik. I cann bring myself to accept that a lovele society can exist, and constantly lo for something I must have missed, fe ing all the while that it is not there. T Ik are not a people one can dislike, much as one dislikes almost everythi they do, feeling that even animals wou behave with more consideration for ea other. One cannot dislike them becau they themselves are without the abil to like or dislike, except with regard the fullness of their bellies: in perso relationships there is a total hiatus.

At the moment it is impossible for not to be largely subjective. There always the hope that once I am out the field, back in familiar and comf able surroundings, with the leisure a strength to go over every detail in sea of the truth, a different truth w emerge. Yet with all this in mind I f that the truth has already been fou It makes me both angry and sad.

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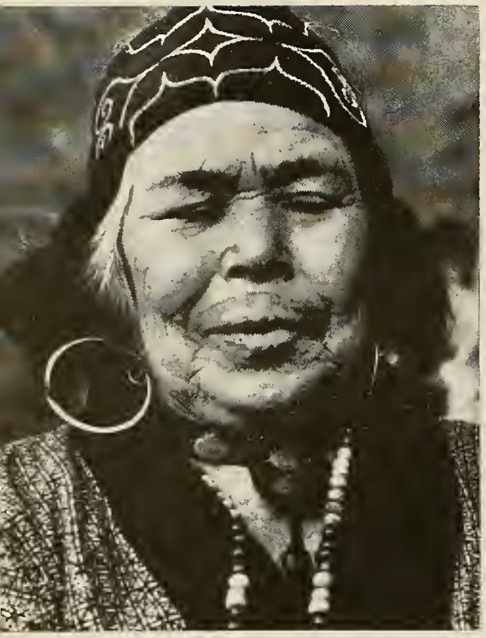


Old Ainu woman with tattooed lips is one of the few who can still speak the ancient tongue. She lives on Hokkaido.

Vanishing Ainu

How the primitive culture of a people who may be of Caucasian origin has succumbed in fewer than 200 years

by SHIN'ICHIRO TAKAKURA

An anthropological tragedy of World War II was the destruction of the last chance to study at firsthand the primitive culture of the Ainu people before it totally disappeared. The remaining Ainu live on Hokkaido, northernmost island of the Japanese archipelago. Perhaps about a hundred "pure" Ainu are left, but only in the sense that each retains pure Ainu blood. Culturally, every Ainu of today is "diluted."

As a race that had its own lan-

Ainu dressed in hunter's costume stands before ceremonial peeled poles (inau), which are topped with bears' skulls.

# of North Japan

guage, religion, method of house building, and other cultural traits and institutions, the Ainu are a thing of the past. There are what people call "Ainu villages," but this is just a name. Any distinctively traditional way of life is preserved only as a tourist attraction. Today, the Ainu live as the Japanese live—except that many are poorer than ordinary Japanese workers and farmers.

Assimilation and acculturation has been a long and gradual process, going back 500 to 600 years. But it was not until after the turn of the nineteenth century that a decisive change came in the life of Hokkaido. Indeed, in the northeastern part of the island, the Ainu were not assimilated until a few decades ago.

In the sixteenth century the Ainu were distributed more broadly than on Hokkaido alone—throughout all the Kurile Islands, the southern part of Sakhalin, and the northern edge of Honshu, the largest of the Japanese

Young Ainu wears a full beard as sign of manhood. He is 24 years old and works as both a sculptor and a dancer.

Mayumi Kameda is an attractive Ainu girl with the look of Asia Minor. She designs textiles in village of Akan.

Contrast in features of old Ainu, Kichiro Iga, and grandchildren shows how traits of pure Ainu are disappearing.

The islands of northeastern Asia were once widely peopled by the Ainu, who now survive only in part of Hokkaido.

islands. Even then there were only about 40,000 of them. Epidemics from the end of the eighteenth century until the early part of the nineteenth century reduced the population even further. Today, most Ainu people are so mixed with the Japanese race that it is virtually impossible to find statistics for the existing Ainu population, remnants of which still live along the Pacific coast of Hokkaido.

Hokkaido is an island of approximately 34,000 square miles, nearly a fourth of the total area of Japan today. Over 70 per cent of Hokkaido is mountain and forest land, but there is proportionately more plains land that can be cultivated than in Japan in general. The latitude is about the same as the northern half of Italy (41° to 45°), but cold currents in the surrounding seas produce a climate similar to that of northeastern New England or the Maritime Provinces of Canada. Winters are long and severe; then summer brings mean maximum temperatures of about 80° F.

Because of these cold currents, sea mammals may be seen on the coastlines (sea otter, northern fur seal), and there are many varieties of fish in the sea and rivers. On land, there used to be many bear, deer, foxes, and a variety of birds. Their number is considerably lower today as the result of farm settlement—much as in the American West. Before the Japanese began to open the forest, cultivate the land, and exploit the resources, all of which started on a large scale in the 1860's, Hokkaido was mostly covered by forests of birch, poplar, oak, elm, fir, spruce, and pine; there were bushes, shrubs, and an undergrowth of bamboo and other wild grasses.

The inhabitants of this wilderness used the word Ainu when referring to themselves. It meant simply "man." Until the middle of the nineteenth century, the Japanese called them *Yezo*, which originally meant "alien people who live in the north."

In physique, language, customs, manners, and religion, the Ainu differed sharply from the Japanese and other Mongolian people. Physically they were different from other Mongol types in having long heads with broad, flat faces. Eyebrows were high over round, sunken eyes that lacked the typical oblique corners. Their skin was comparatively white, the color of their eyes usually brown (but sometimes blue). These physical characteristics persist in the diluted Ainu today. Some anthropologists believe that the origin of the Ainu was Caucasia, from which they traveled across Siberia, eventually reaching Hokkaido. Probably the Ainu retained the characteristics of prehistoric people of an age before the human race diversified into Mongoloid and Caucasoid, if such a diversification actually occurred.

The Ainu language—as studied and preserved by scholars—borrowed many expressions from neighboring peoples, but it still had distinct characteristics of its own. The language has now been almost completely replaced by Japanese. Although still remembered by a few old people of the Ainu, it is not used in ordinary conversation, but only in prayers and folk songs.

Until the Japanese introduced cultivation to Hokkaido, the Ainu knew nothing of agriculture. In the warm seasons they fished, in the autumn they gathered nuts and the roots of wild grass, and in the winter they hunted. There was no need for agriculture as long as they could get enough food without it. But the mi gration of Japanese into Hokkaido in the 1860's narrowed the room fo wildlife and polluted the streams, s the population had to turn to cultiva tion for a food supply. Until tha time, the Japanese had not encour aged agriculture in Hokkaido, be cause they profited from trading ag ricultural products, such as grain and tobacco, for furs from the Ainu

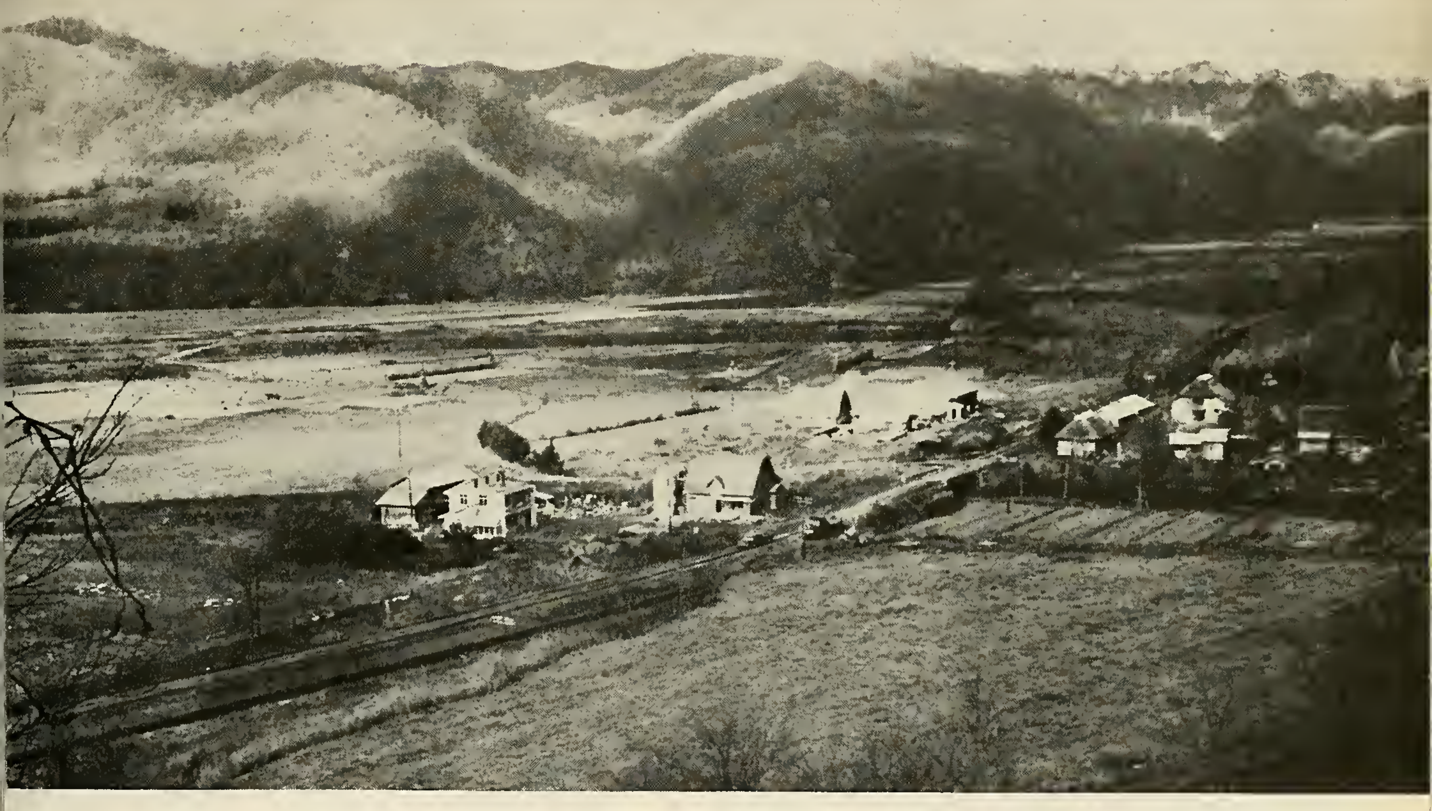
The Ainu necessarily worked t gether as a tight community, an goods were distributed according t the needs of the communal societ Small as this society was, howeve there were class structures, which i cluded poor and wealthy classes an a limited system of slavery. Th slaves were captives of the wars b tween villages or those who could n maintain themselves in the comm nity—widows, orphans, the mental retarded, or those who could not pa a "fine" for breaking communi rules. The division of labor was ve strict. The men hunted and were r sponsible for ceremonial activitie the women did the housekeeping.

Each village was led by a ch who handled all administrati matters, including war, and was charge of various ceremonies.

Much tribal administration w based on tradition, and anyone vi lating the set rules was tried by a sp cial discussion system that the Ai called *charanke*, which means "

' home, a storehouse on stilts, and ther buildings were recently erected) show traditional living conditions.*

lodern village of Nibutani, with the rgest Ainu population on Hokkaido, ears little resemblance to the past.



gue." When a violation occurred, othing happened unless there was a mplaint. Ordinarily, someone who ffered damages or felt aggrieved ould demand that the accused be inished or that the devil that made e man do wrong be driven away. ne two persons (in some cases oups) concerned would discuss the atter between themselves. If they ached a decision satisfactory to th sides—one party to sacrifice mething he possessed, or become a ive to the other, or the two to beat ch other with clubs, or whatever e might be agreed—this decision is carried out and it was all right th the other villagers. But if the o could not reach a mutually acptable decision, then a third party ervened—an elder man of the village—and the disputants argued before him. If no satisfactory solution resulted, the two disputants would beat each other with clubs and that ended the affair. The clubs, called *shut*, were two to three feet long and looked like modern baseball bats. The beatings were not perfunctory, but full of force. However, they were not a test of strength; rather, they were meant to drive away the devils and were ceremonial in nature, probably originating in Ainu religion.

After the 1860's, the Japanese government took administrative and judicial power over Ainu villages into its own hands. This process, together with the advance of capitalism and the deterioration of the old ecology, deprived Ainu villages of the unique nature of their community life and destroyed the integrity of their social life. As a result, an Ainu village became just a hamlet where the inhabitants were Ainu, not a community where Ainu lived as they used to live.

A distinctive feature of the Ainu culture was house construction. There were slight regional differences in structure and materials, but the basic techniques were the same for all Ainu. The houses were one-room structures and always faced a fixed direction—usually the east or, if not, the direction from which a river flowed. Facing upstream meant toward the mountains, where the gods were supposed to live. There seem to be two intermixed religious ideas: one, gods come from the east; another, gods come from the

Eldest son of the owner prays for luck on site of new Ainu house. The stick in tripod marks location for fireplace.

mountains. But about this we have no definite information.

The building was a long, rectangular single room. The main windows opened only on one of the narrower ends—the front—and their purpose was to permit gods to enter the house. The entrance for the occupants was on the opposite side, and next to it were the cooking implements. There was no window on the long right wall, but a small window on the left admitted light. Straw mats spread over hay covered the floor. The unthatched ceiling was of attractive shingle construction. On festive occasions, the walls and floors were decorated with mats of patterned designs. Over a large fireplace in the room's center hung pots and pans and a shelf for drying clothes, food, and other things that needed drying. Smoke escaped from triangular windows on the edge of the roof. The fire always burned, for this was the seat of the fire goddess, who protected life.

The left corner farthest from tl entrance was the most holy; here tl god who was the husband of the fi goddess was enshrined as the prote tor or guard of the house. A piece shaved wood that symbolized the g was hung on the wall. Festival orn ments and treasures, such as la quered woods, swords, and necklac that were obtained in trade with tl Japanese, were also hung or set this corner of the house.

When a family entertained, tl host and hostess sat beside the fi the rest of the family sat a little fa ther away toward the entrance to t house, and guests were placed opp site the host and hostess. This seati order was strictly observed.

Storage buildings near the hou entrance were oriented in the sa

Ceiling and roof frame are first part of house to be built.

While still on ground, the roof frame is covered with gras

With community helping, roof is lifted atop the wall posts.

House is completed. Sacred window is at right, with cove

direction as the house. The latrine was separately built on the opposite side of a hedge.

The head of the family chose the homesite. He stuck a stick into the proposed location and prayed. If he did not have a bad dream afterward, he constructed his house on that spot, helped by the whole village, and a fete was held when it was completed. In ancient times only the chief's house was big, well furnished, and set apart from the others.

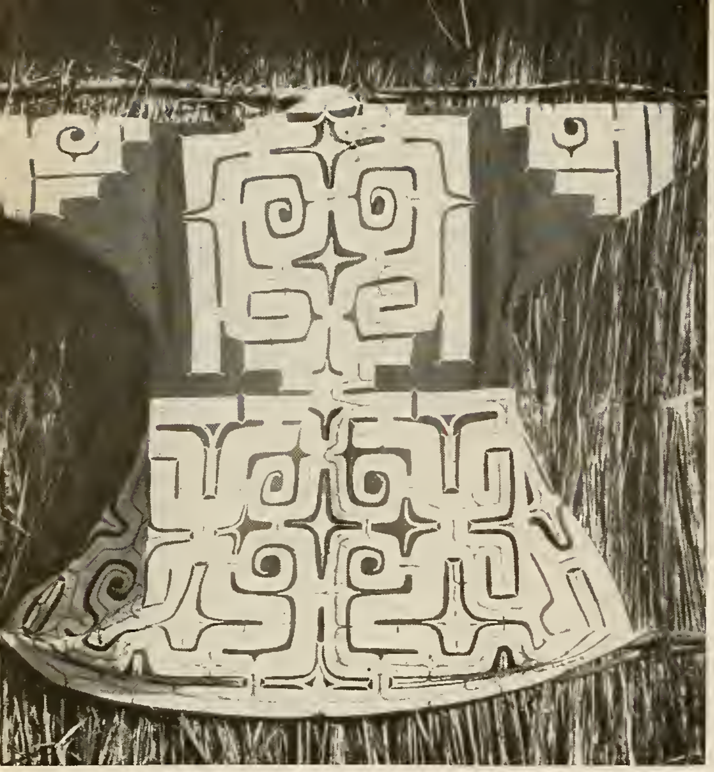
The house was constructed literally from the top down. First, two tripods were erected by tying wooden poles with rope made of vines or bark. Then the beams of the ceiling frame were fastened together in a rectangle on the ground. The tripods were put upon the ceiling beams, a ridgepole placed atop the tripods, and all tied together. This was the ceiling and roof frame. Additional sticks were added from ridge to ceiling, and the roof was covered with grass, bamboo, and bark tied to the framework. Eight or ten posts were sunk in the ground selected for the house. The builders lifted the whole ceiling and roof assembly and placed it on the posts. Walls were made by attaching grass, bamboo, and bark to the posts. Ordinarily the house was about 12 by 18 feet.

Clothes were made of fur or of *attsushi*, cloth made from fibers of elm phloem just inside the bark. Later, as trade was established with the Japanese, cotton became common. Ainu clothes resembled the open-fronted Japanese kimono. Collars, back, sleeves, and hems were embroidered or appliqued with unique Ainu designs, specific to each community. Needlework was the favorite occupation of the Ainu women, who learned the traditional designs in their childhood and did exquisite work with a small knife and a needle. Under the kimono the women wore a one-piece garment to hide their breasts. Usually, both men and women wore a headband, gloves, and socks decorated to match the kimono. From the men's belts hung a small knife scabbard made of wood and decorated with beautiful carving executed by the men. The Ainu wore hoods in winter, and shoes made of salmon or deer skin or sandals made of grapevine bark, but in other seasons they usually went barefoot.

Adults cut their hair at shoulder level and parted it at the center. The men had thick beards; the women were tattooed about the lips and on the backs of their hands and arms. Men's beards and women's tattoos were indications of adulthood. The tattoos were made by rubbing soot into shallow cuts in the skin.

At ceremonies, both men and

Ceremony, held at central fireplace, marks opening of Ainu house. Owner presides, holding sake bowl and cup.



Applique design, done by hand on woman's cotton coat, is an example of Ainu decoration. This pattern is called Moreu.

Scabbard of carved wood is typical of Ainu craftsmanship. Beneath long sword on right is carved wooden tobacco box.

women wore special decorative kimonos, over which they put foreign clothes, such as the long Japanese coat called *uchikake*. The men wore crowns sculptured of wood and decorated with straw, and long swords strapped across the right shoulder to the left waist. The women put on more decorative headbands and necklaces, and both men and women wore large metal earrings.

When traveling, the Ainu man carried a Y-shaped walking stick. He wrapped his food in a mat, suspended on his back by a rope around his forehead. The mat was useful when he slept, and the walking stick could be used as a spear. A quiver holding wolfsbane-coated arrows and a machete-like knife hung at the waist.

The Ainu were good hunters and skillful trappers who knew the animals' trails. One type of trap was constructed in the following manner: A trigger string was concealed under grass and stretched across a trail. A bow with fully drawn arrow was fastened alongside the path, and the trigger string was connected to it with ropes and sticks. The arrow was aimed at the point where an animal's heart was likely to be when its forepaw touched the trigger string. Another type of trap used a heavy wooden block.

Except for the Ainu in Sakhalin, who utilized dog-drawn sleds, the Ainu had no means of land transportation other than walking. In deep snow they used snowshoes called *teshma*. On the river they took to wooden dugouts. When sailing on the ocean they used the same kind of canoe, attaching a side board and raising a mat for a sail. At night they landed on the beach and made a shelter with the mat. The next day they resumed their travels.

The religion of the Ainu was animistic, and they believed gods existed everywhere. They always worshiped before embarking on any activity, as well as at times of disease and calamity. Pleasant gods were solemnly welcomed with ceremonies and prayers and sent back to heaven. Unpleasant gods were "kicked back to hell" with curses and threats. In both cases, dolls made of wood were considered to operate as intermediators between men and gods. The *ikupasui*, a small stick that was one of the utensils accompanying the sake bowl, was believed by early students of the Ainu to be purely utilitarian—a tool from the sake cup. Later, investigators discovered that, on the contrary, the *ikupasui* was one of the Ainu symbols of a bird; it took sake offerings to the gods.

The Ainu believed that the gods, in their country on the tops of high mountains or in the east, lived the same kinds of lives as human beings, using human foods and offerings. When gods visited the Ainu world, they impersonated animals. For example, the hunting god came as a bear bringing meat and fur to the human world. It could be caught only by a young man whom it had chosen to visit. Therefore, the Ainu had a festival when they caught a bear, and offered many prayers that he would visit again. They would then kill the

On the shore of Akan Lake, Ainu girl learns to execute design like those traditionally used on women's headbands.

bear for its meat and fur and send its soul (that is, the god that brought the meat and fur by impersonating a bear) back to the country whence it had come.

When a bear cub or other animal cub was caught, it was kept in a wooden cage specially built for the purpose until matured, because the Ainu believed it could not go back alone when so young. The cage was kept in a fenced-in area outside the god window of the house of the favored youth who caught the cub.

In the autumn, when the cub was about two years old, a festival was held. A special sake was prepared, and messengers were sent to invite the young man's relatives and neighbors. The guests, clad in their best clothes, gathered at the host's house and made rice dumplings and *inau*. *Inau* were sticks of various sizes, small enough to be easily held in one hand, that were decorated with shavings and shreds made by peeling the stick with a knife. Like *ikupasui*, *inau* symbolized birds. (In Ainu religion, birds were intermediaries between men and gods.) In prayer, an Ainu told his wish to the *inau*, who conveyed the message to the gods. Offerings for the gods were also put before the *inau*.

The host, acting as master of ceremonies, approached the bear cage and declared that a farewell ceremony was about to begin. He then designated another young man to draw the bear out of the cage with a rope and to bring it before the *inau* hedge—a fence made of the whittled and shaved wooden sticks. Men drew carved ceremonial arrows that were variations of *inau*, blunted at the ends to prevent their penetrating the bear's skin. The host shot the bear in the heart with a regular, sharp arrow. Then the animal's neck was placed under a log, which the people jumped on to strangle the bear—even if it had been killed by the arrow. At the same time, they shot blunt arrows heavenward to insure the safe return of the bear's soul to the god country.

The dead body was offered to the *inau* hedge and later skinned, except for the head, which was placed in the seat of honor beside the fire. Then a drinking party began. Many sake bowls accompanied by *ikupasui* would be handed among the men, who drank freely after they had offered a drop for the god. The climax of the fete was reached when the women began to sing and drum on the tops of sake vessels and men and women began dancing together. At midnight, the skin was peeled from the bear's head, and the skull was placed on a stick decorated with wood shavings, and offered on the hedge, where it remained indefinitely. The more bear skulls they could exhibit, the more prosperous and happy the family was.

Shamanism—communication with the gods through mediums—was also part of the Ainu religion. While Ainu women could not pray or celebrate the gods directly, the gods could possess them. Thus, Ainu shamans were women who, when possessed, reached a psychological state called *imu*. When in such a state, the shaman babbled, was convulsed, and otherwise acted erratically, uttering what the Ainu believed to be messages from the gods.

The Ainu had an oral literature in the form of long poems called *yukara*. (There were no Ainu letters, and we have no written record.) The poems were recited or, rather, sung to individual melodies by a storyteller of the village. The storyteller (or *yukara* singer, we might say) was, in most cases, an old man or woman. But the storyteller had no monopoly; everybody in the village learned how to recite *yukara*. Some were better than others in recitation and memory, and one of the ablest was selected as the official storyteller of the village. He recited the poems during the evenings of ceremonial days, or, if asked by the villagers, on ordinary evenings.

At one time *yukara* were epics believed to be the voice of the gods describing their ceremonies. In Ainu language, *yukara* originally meant "to imitate" or "to mimic." They were always told in the first person and always ended "So said the god." This indicates *yukara* may have begun as the ceremonial songs or prayers of the shamans.

Later, *yukara* became poetry that, characteristically, told of the acts and loves of a young hero called *Poiyawumpe*, a god's son brought up by human cousins. Just, generous, and brave, he fought for, and finally won, a beautiful girl he had rescued from a disaster, from a "bad guy," or from a devil. These stories, too long to be told in one night, were comparable to the Homeric epic.

Yukara were passed from generation to generation. Just before they vanished from the Ainu culture, the few now known to us were discovered and collected by Dr. Kyōsuke Kindaichi, former professor at the Uni-

versity of Tokyo, Faculty of Letters, who translated them into Japanese.

In addition to the *yukara*, the Ainu had lullabies, love songs, rounds, and simple dances. Among them, the "Dance of Cranes," which imitates the movements of the birds, was particularly popular. The Ainu possessed no musical instruments, but they beat time with their hands for their songs and dances.

Death was a terrifying thought for these people, who believed it to be a punishment of the gods. Epidemics of measles, smallpox, syphilis, and tuberculosis, all brought by the Japanese, killed many Ainu, who believed that the illnesses were spread by a devil. To counter the epidemics, the people set up *inau* on the border of the villages or coasts and spread filthy things over them so the devil could not approach habitations. Devils were supposed to dislike excrement or decaying vegetables, fish, or animals. (Sometimes a child was named "Feces" or "Dung" so the devils would not take him.)

Methods of treating disease were primitive. Those who were ill were beaten with wormwood sticks or forced to creep through fire. Sometimes their faces were smeared with kettle soot, after which they were driven into the woods.

If the victims died, much concern was shown. Relatives and neighbors offered farewell prayers. The bodies were dressed in specially prepared clothes, covered with mats, and buried in a shallow grave over which graveposts were erected. These posts varied according to the sex of the deceased and the region from which he or she came. For example, in the Hidaka area, which supported the densest Ainu population, men had spade-shaped graveposts; those for women were needle-shaped, with holes.

After they buried the dead, the mourners hurried back home and never again visited the grave. The house of the deceased was burned to prevent the return of the devil of death. (In later years, lacking construction materials, the mourners merely changed the position of furniture, and the living members of the family changed clothes so the devil could not recognize them.)

Accidental death was so hated that when it occurred all the neighbors gathered, threatened the devil with swords and screams, and beat the surviving members of the family.

Bears, considered to be messengers between gods and people in old Ainu religion, are still cherished as pet[s]. This scene is in the village of Aka[n]

After the Meiji restoration (1868), which followed the opening of Japan to Western influences, the Ainu were integrated with Japanese immigrants in Hokkaido and received the same education as the Japanese. Today, therefore, almost no Ainu can speak his ancient language, which is now preserved only in the names of some cities and villages in Hokkaido. Tattooing is prohibited, and the Ainu's daily life is no different from that of the Japanese. Ainu villages have disappeared, and their religion is lost.

The opportunity to study the old way of life is largely gone. There was in World War II an intensified Japanese ideology that all people in the country were the Emperor's subject[s] so that the study of the Ainu as a rac[e] distinct from the Japanese wa[s] frowned upon by the governmen[t]. Also, during, and immediately afte[r] the war researchers could not pa[y] much attention to investigation of th[e] Ainu, because of the mobilization o[f] all human and natural resources fo[r] the war and because of the confuse[d] and unstable social circumstance[s] thereafter. Since 1941 we have had [a] time of great social change for th[e] Japanese in general, and the pace o[f] social and cultural change among th[e] Ainu has also quickened.

It is regrettable, from an ethno[-] logical point of view, that the Ain[u] people are vanishing, but accultur[a-] tion has helped to solve some of the[ir] problems as a minority group.

Grave poles are an Ainu tradition [in] use today. Pole at left marks gr[ave] of a woman; the one above, a ma[n].

In olden days bears were killed in ceremonies, and their "souls" were sent back to the gods from which they were believed to have come. Skulls were kept on top of poles, such as these at the reconstruction of an Ainu settlement.

Flowering Stones

Why these South African plants are so well camouflaged remains a mystery. Propagating them is now a popular gardening challenge

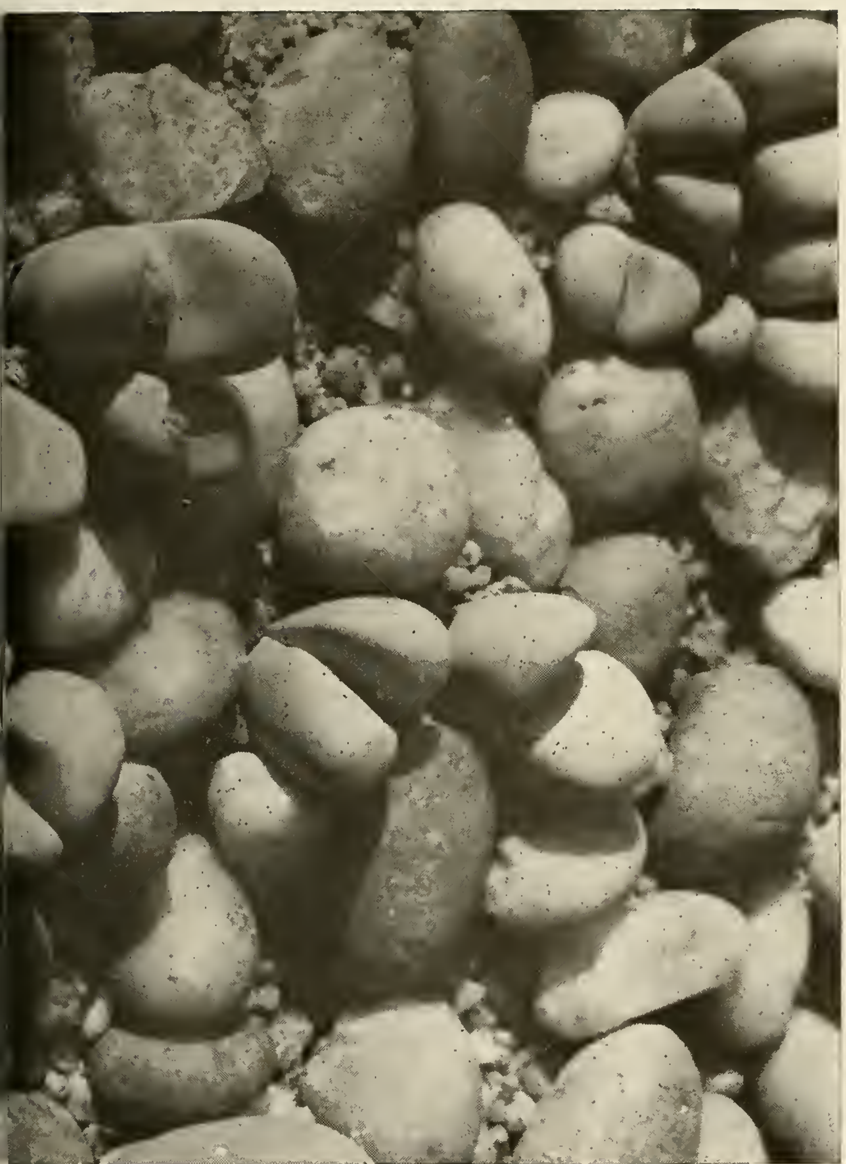
by David S. Hardy

The early Hottentot peoples referred to the vast stretch of country that lies northeast of Cape Town as Karroo, a word that means "barren" or "bald." Great numbers of strange, succulent plants are present throughout the Karroo area—tall, white-stemmed aloes; fascinating, flesh-colored carrion flowers; and, strangest of all, the peculiar group of plants known as flowering stones. These are endemic to South and South-West Africa and are members of the family Mesembryanthemaceae.

In his monumental book *Travels in the Interior of Southern Africa,* published in London 1822-24, the British explorer William John Burchell made the following observation: "On picking up from the stony ground, what was supposed a curiously shaped pebble, it proved to be a plant, and an additional new species to the numerous tribe of *Mesembryanthemum;* but in color and appearance bore the closest resemblance to the stones, between which it was growing." This discovery took place in the Prieska district of the Karroo in September, 1811, but because Burchell's original drawing was lost or destroyed, it was not until 1918 that Dr. I. B. Pole-Evans of Pretoria rediscovered the plant in the same area. Dr. N. E. Brown, an English botanist, named the plant *Lithops turbiniformis,* the word *Lithops* being derived from the Greek *lithos,* a "stone," and *ops,* which means "face." Although the wandering Bushmen featured a number of animals and plants in their rock paintings, no attempt seems to have been made to depict *Lithops.* The Hottentots now call the plants *Skaap kloutjies* ("sheep's hoofs").

Of the many kinds of flowering stones, the eighty species of the genus *Lithops* are the best-known. Each plant consists of two somewhat contiguous leaves on a short stem, the cross section of which is circular. These two leaves form an inverted cone, its base exposed to the atmosphere and its apex embedded in the soil. Cells containing chlorophyll line the inner surface of a tissue that forms the outer layer of this buried, inverted cone. Green plants depend on light to manufacture food, and *Lithops* has evolved in an interesting way to overcome its structural peculiarities. All the light reaching the chlorophyll cells must pass through the window-like tops, which lie level with the surface of the soil. In some species the top is completely transparent; in others there are a number of windows—small transparent areas with opaque tissue between them. Visualize a cup filled with translucent tissue fused to the cup—this is the pattern of *Lithops.*

The plants have to withstand tremendous changes in temperature. Professor Kurt Dinter, an early German botanist, measured the temperatures to which a *Lithops* in South-West Africa was subjected. In summer he found the air temperature to be 133 degrees Fahrenheit; when the plants are dormant in winter, the



Many species of flowering stones, such as Lithops meyeri *(left), can barely be distinguished from rocks and ores.*

While these plants rarely flower prolifically, the blossoms of flowering stones are often highly scented and, when fully opened, are visible from a long way off. Cross-pollination of *Lithops* is accomplished, for the most part, by honeybees, small hover flies, and some night-flying insects. Despite the close relationship of some species the plants do not easily hybridize, even in cultivation.

The most widely distributed species is *Lithops lesliei.* It has a north—south range of about four hundred miles. Studies indicate that this yellow-flowered species has migrated to the north. This comparatively wide distribution contrasts with the restricted areas of most of the other eighty *Lithops* species.

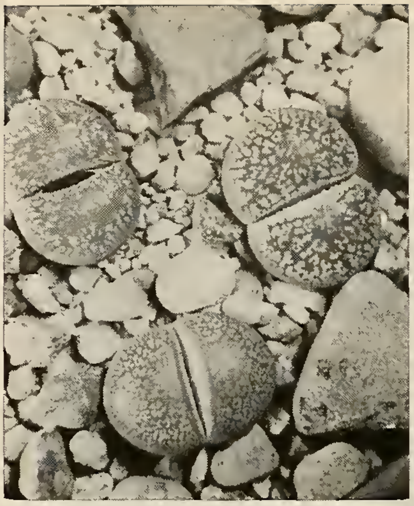
L. turbiniformis, the plant first described by Burchell, appears to be confined to the Prieska district, where it is still found in large numbers: the flat-topped, pebble-like bodies blending completely into the background of broken sandstone. This species has bright, canary-yellow flowers.

L. terricolor seems to be the only member of the genus known to grow as far south as the southern border of the Karroo. This plant is found in

temperature may sink as low as 14 degrees Fahrenheit.

One of the most peculiar features of flowering stones is the structure of their seed capsules. These capsules may be the most intricate and most highly organized in the vegetable kingdom. They consist of a number of chambers, each of which is usually covered by a "lid." When the seeds are ripe, the mechanism of the lid becomes sensitive to moisture. When wet by a shower of rain, the lid opens slowly, allowing seeds to escape or be washed out. As soon as the capsule dries, the lid closes. The seeds of many species are viable for long periods; some *Lithops,* for example, have been known to germinate after being kept for fourteen years. During the dry season most stone plants go completely dormant, and some are able to do without rain for more than a year. *Lithops ruschiorum,* for example, grows along the coast of the Namib Desert in South-West Africa where the rainfall rarely exceeds half an inch a year. These plants appear to lose a minimum of moisture—a large plant weighing 11.5 grams when fully exposed to the sun was found to lose only 0.2 grams in 15 days. Apparently they are able to survive on moisture extracted from heavy sea mists that rise from the Atlantic Ocean during the night.

Vast shaded area lying northeast of Cape Town—known as the Karroo—is where many flowering stones grow.


Three stages in the growth of Lithops aucampiae *are shown above. Sometimes there is an interval of two to three years between germination and flowering. Photograph at right shows two hybrid plants,* L. karasmontana, *in full flower.*

fairly large numbers in and around the Beaufort West district; the gray plant bodies, as a rule, are covered with small, irregularly spaced black dots. In one form, however, the dots are dark red in color. The flowers of this species are bright yellow.

Dinteranthus pole-evansii, named after Professor Dinter and Dr. Pole-Evans, grows in the same region as *L. turbiniformis*, but its round, white, pebble-like bodies are confined to white quartzite formations. Its flowers, however, are yellow and highly scented. The main differences between the two genera, *Lithops* and *Dinteranthus*, are the structure of the seed capsules and, in some cases, the shape of the plant body itself.

Although stone plants are known to grow in both summer and winter rainfall regions, they seem, for some unknown reason, to favor the latter. The winter rainfall area known as Namaqualand is particularly rich in these plants. Another genus, *Conophytum*, is concentrated in this region, and the plants are generally confined to rocky outcrops or scanty soil deposits. Most of the required moisture comes from heavy mists or from dew that condenses on the rocks. A notable exception, *Conophytum pillansii*, is found in deep soils surrounded by white quartzite in the Van Rhynsdorp district. Still another genus, *Argyroderma* (meaning "silver skin"), is confined to this area and is found nowhere else in South Africa. Flower coloration varies from deep golden to light plum, depending on the species. The various species of *Dinteranthus* never occur very far from the banks of the Orange River and are always found growing in white quartzite.

While this limited occurrence is characteristic of stone plants, so also is the manner in which they blend into their surroundings when not in flower. Members of the genus *Gibbaeum* (meaning "hump") are confined to certain districts in the Karroo. These plants grow in large clumps that are difficult to find in the dry season, their shriveled, silvery bodies blending perfectly with the white quartzite background. Another case of camouflage is *Pleiospilos bolusii*, known to the children of the Aberdeen district as the "liver plant." It has the appearance of dried liver, and can hardly be distinguished from the chunks of iron ore on the surface of the soil in which it is found.

The adaptive camouflage exhibited by most flowering stones is, in fact, their most remarkable and puzzling aspect. It is thought by some to be a protective device against browsing animals, but as the antelopes that are known to eat the plants rely on their sense of smell, rather than sight, this hypothesis is condemned by many.

There is a theory that plants growing in quartz may need to reflect light in order to prevent them from absorbing too much of it, and thus they simulate the light-reflecting surface of the surrounding rocks. But while this may explain the color of these plants, it still does not account for their shape.

We have yet to discover why other flowering stones "imitate" the brown color of broken slate and sandstone, or why still another has white, warty excrescences on its leaves that are indistinguishable from the weathered limestone in which it grows. These questions, and others relating to the adaptability of the flowering stones, still remain to be explained.

Flowering Stone Culture

Growing flowering stones and related succulents has become a popular challenge to the indoor gardener. Many varieties of plants are available at florists and nurseries, and even the seeds can be purchased from dealers specializing in rare and unusual plants by those who wish to grow their own *Lithops* from scratch. The basic requirements are a finely sifted growing medium of one-half soil and one-half sand; as much sunlight and fresh air as possible; and a low temperature at night (but not below 50°F.).

Success for the amateur in growing flowering stones depends on great restraint in watering. Practically no water is required during their dormant period, even though the skin of the plant may look withered. The soil should be allowed to dry out between waterings, no water should touch the exposed part of the plants, and the soil should never remain saturated. For maximum drainage, grow the plants in small pots set in larger ones filled with fine gravel. Water is then applied to the gravel in the larger pot.

The Tiger and Its Prey

This scene is typical of the study area in the reserve. Here can be found hill forest and open grasslands, permitting observation of all the species of deer.

by
George B. Schaller

Modern man tends to look at wolves, lions, tigers, and other large predators with a deep-seated antipathy and intolerance. In part, this may be the result of descriptions such as the following one by Theodore Roosevelt of a puma cornered by hunters: "the big horse-killing cat. the destroyer of deer, the lord of stealthy murder, facing his doom with a heart both craven and cruel." In this one sentence he not only denounced the supposed character of predators and emphasized the fact that they occasionally cause economic losses by killing livestock, but he also intimated that they are detrimental to deer and other wildlife populations in which man has a vested interest.

Although it can logically be assumed that the large predators exert an influence on prey populations, studies to determine the extent of that influence have rarely been made. Do they kill animals of all ages indiscriminately? What percentage of the prey population do they remove each year? How often do they kill, and what is the size of their daily food intake? These and many other questions must be answered before the effects of predation can be assessed.

e influence of tiger predation on the rious populations of prey—both wild d domestic—in Kanha National Park, lia, is estimated in this article.

During 1964 I studied the tiger and its prey in Kanha National Park, a small nature reserve in the highlands of central India. In the past few years the increase in the number of tigers in the park, coupled with a decrease in the number of deer, led some of the forest rangers there to the conclusion that the cats were responsible, and a reduction in their number was contemplated. One of my tasks was to find out if a predator control program was justified.

My study area was a broad valley in the center of the park—some twenty square miles of forest broken by meadows of varying sizes and surrounded by a low range of hills on three sides. The forest in the hills was stunted, and the trees were mostly deciduous, dropping their leaves during the hot months of the year. In the lowlands, on the other hand, the forests consisted primarily of tall sal trees, whose larger, ovate leaves provided shade at all times. Working conditions in the valley were in many ways ideal. In contrast to most other Indian forests, disturbance by man and livestock was relatively slight. Wildlife was abundant, and much of it was concentrated there, particularly during the hot season from March to June when the available water consisted of a few pools and temperatures in the shade were 110°F.

The tigers in Kanha Park had their choice of a wide variety of wild prey animals. The most abundant of these was the chital, or axis deer, a lovely animal about the size of a white-tailed deer, with a spotted coat. Some six hundred chital resided in the study area, preferring the edge of the forest, where at dusk and dawn they appeared in herds numbering anywhere from four or five to more than one hundred.

A second species of deer was the stately barasingha, a close relative of the European red deer. In 1964 only about eighty barasingha still survived in the park. Their large size, sociable habits, and predilection for grasslands on which to court, feed, and rest make them such an easy target for the poacher's gun that the species has almost been exterminated in India.

The largest, as well as the most elusive, deer was the sambar. Although some fifty to sixty of these wapiti-sized animals resided in the area, I did not see them often, because the small herds—rarely comprising more than four individuals—retreated into dense forest during the day.

The gaur, a form of wild cattle, were represented by about 125 to 150

Black facial markings of tigers are so highly distinctive that it is possible to differentiate between the individual animals on this characteristic alone.

animals. These impressive bovids—the bulls reach a shoulder height of 6 feet and a weight of 2,000 pounds—are, like the sambar, primarily nocturnal. Herds, numbering five to twenty individuals each, commonly graze on the meadows until dawn and then withdraw into the bamboo thickets on the slopes of the hills. Wild prey of minor importance include langur monkeys, the small barking deer, pigs, porcupines, and a few other species.

The most abundant hoofed animals in India, and also the tigers' most important source of food throughout the country, are the domestic cattle and buffalo, millions of which roam the forests unattended. Fortunately, only about sixty of them were in my study area, in contrast to the edge of the park, where over 2,500 grazed.

The easiest means of determining which of these potential prey animals the tiger eats, and the extent to which it does so, is to examine its feces, or droppings. In eating an animal the tiger devours the skin and hair, bone splinters, and sometimes hoofs and teeth, all of which can be used to identify the victim. I collected and examined 335 droppings (*table 1, page 33*). In over half of them the remains of chital deer were found, followed by sambar, barasingha, gaur, and domestic livestock, in that order. These animals formed the great bulk of the tiger's diet.

The late Paul Errington generalized that "the large-sized wild ungulates [hoofed animals] suffer from subhuman predation chiefly when immature, aged, crippled, starved, sick, or isolated from their fellows." Studies on wolves in North America have tended to support this contention. Adolph Murie, for example, found that the wolves of Mount McKinley National Park, Alaska, killed mainly the young, old, and diseased Dall sheep, leaving the most vigorous adults to propagate; L. Mech came to a similar conclusion after observing the interactions between wolves and moose on Isle Royale, in Lake Superior, Michigan. Wolves hunt largely by running down their prey, whereas the tiger stalks its victim, before attacking with a final short rush.

I depended a good deal on teeth to determine the ages of the animals killed by tigers. Premolar and molar teeth erupt in a definite sequence when the animals are young, and wear down over the years. A relative age can be assigned to animals killed by predators on the basis of tooth eruption and wear. I established nine age classes, ranging from class I, young less than one year old whose second and third molar teeth had not yet erupted, to class IX, old animals with the cheek teeth worn close to, or

The long-antlered, delicately spotted chital, or axis deer, were the most abundant of all the animals on which the tigers of Kanha Park could prey.

TABLE 1

'REQUENCY OF OCCURRENCE OF FOOD TEMS IN 335 TIGER FECES COLLECTED IN 'HE STUDY AREA, KANHA PARK, IN CAL- :NDAR YEAR 1964.

'ood Item	Frequency of occurrence	
	No. of feces	%
:HITAL	175	52.2
;AMBAR	35	10.4
JARASINGHA	29	8.6
;AUR	28	8.3
.ANGUR MONKEY	21	6.2
)OMESTIC CATTLE	20	5.9
;OIL	13	3.8
'ORCUPINE	9	2.6
;RASS	8	2.3
)OMESTIC BUFFALO	6	1.7
'IG	3	.8
'ROG	1	.3
:GGSHELL	1	.3
'ERMITE	1	.3
'RUIT	1	.3

TABLE 2

NUMBER OF PREDATOR KILLS IN EACH AGE CLASS OF 3 SPECIES OF DEER (EXCLUDING FAWNS IN CLASS I).

Age class	CHITAL		BARASINGHA		SAMBAR	
	No.	%	No.	%	No.	%
II	10	11.0	3	9.0	1	2.0
III	8	8.5	4	11.5	7	13.0
IV	7	7.5	7	20.0	2	4.0
V	14	15.0	5	14.0	3	6.0
VI	9	9.5	4	11.5	6	11.5
VII	21	22.0	7	20.0	14	26.0
VIII	16	17.0	5	14.0	14	26.0
IX	9	9.5	0	0	6	11.5
TOTAL	94	100.0	35	100.0	53	100.0

TABLE 3

ESTIMATED NUMBER AND WEIGHT OF MAIN PREY SPECIES TAKEN BY PREDATORS IN CALENDAR YEAR 1964.

	Young		Yearling and Adult		
	Estimated no. taken by predators	Total estimated weight in pounds	Estimated no. taken by predators	Total estimated weight in pounds	Total weight in pounds
CHITAL	115	5,750	85	10,625	16,375
BARASINGHA	0	0	27	9,450	9,450
SAMBAR	15	1,500	6	2,400	3,900
GAUR	25	5,000	7	9,100	14,100
DOMESTIC CATTLE	3	450	11	3,850	4,300
DOMESTIC BUFFALO	0	0	5	2,500	2,500
TOTALS		12,700		37,925	50,625

down to, the gumline. However, predators usually consume the soft, weak bones of young animals (those in class I) so completely that they are rarely found. This tends to bias the results considerably. But the death rate can be computed in another way: the loss in class I equals the difference between the total number of young born and the number surviving to enter class II. This calculation showed that about 50 per cent of chital, sambar, and gaur young failed to reach one year of age—a greater proportion of these animals died while young than at any other time. The barasingha had very few offspring—only six were counted—but this was probably due mainly to brucellosis, a bacterial infection causing spontaneous abortion of the fetus, rather than to predation.

The death rate of animals one year old and older showed some important differences between species (*table 2, top, right*). Chital and sambar of all ages fell prey to tiger, but seemingly the greatest proportion of these were the older, rather than the prime, animals. On the other hand, the predators removed deer of all ages about equally from the small barasingha population. Only a small percentage of deer kills were in the oldest age class (IX), and it is likely that few, if any, of them escape the tigers long enough to die of old age. In contrast, tigers killed adult gaur infrequently. The remains of only eight large gaur were found, even though the skele-

As a result of both extensive poaching and the widespread destruction of its grassy habitat, barasingha deer are on the verge of being extirpated in India.

In study area, there were few domestic buffalo, although in the country at large they are tigers' most important source of food. A stalk on one of these animals begins, above, and a female with her nearly full-grown cubs closes in, below.

tons are far more conspicuous, and thus easier to find, than those of deer. Undoubtedly the large size and formidable horns of the gaur deter the cats except under the most favorable circumstances. (For example, I once watched a tigress stalk a bull gaur, but suddenly she changed her mind and walked away; on another occasion a bull threatened a tigress with his horns before retreating from her slowly without being molested.)

The various sources of information thus led to the conclusion that although tigers culled the less fit animals—mostly the young ones, but also the older ones, except the gaur—from the populations, many in the prime of life were also taken. Some of the latter were females that had lost their agility in late pregnancy, but others had no obvious handicap. None appeared to have been weakened by disease or starvation.

For a meaningful study, it was also necessary to compute the total amount of wildlife killed by predators during the year. To do this, the size of the prey population, the yearly death rate, and the approximate weight of the animals taken must be known. The mortality rate of the young has been mentioned earlier, but not that of the adults. As a general rule, in a stable population the number of deaths among adults roughly equals the number of young animals entering the population as one-year-olds. The adult sambar had an annual death rate of about 13 per cent, and their numbers seemed stable. The chital and gaur increased slightly and had an estimated mortality rate of 20 and 5 per cent, respectively. The barasingha decreased by 33 per cent because too few fawns survived to offset the loss of adults to tigers.

These mortality figures can be converted into the actual number of animals killed and also into their total weight (*table 3, page 33*). The table includes nineteen domestic cattle and buffalo, which the tigers are known to have eaten in the study area. Thus the predators, including tigers, an occasional leopard, and some poachers, removed an estimated 50,625 pounds of animals from the study area during 1964. Such food items as monkeys and pigs provided an additional few hundred pounds at most.

Now, the most accurate means of determining the amount of food required by tigers during a year would be to follow them for days and weeks. This is hardly feasible, for tigers usually hunt alone at night and are very shy, keeping mostly to dense thickets and ravines. Their nightly meanderings in search of a victim may take them for 15 or more miles within an area of at least 25 square miles. One night a tigress with four cubs killed a chital buck. The family caught nothing further the following night, but on the third night the tigress attacked a buffalo that had strayed from a village. She and her cubs consumed this animal in two nights. They had killed twice in four days. But I was rarely able to make such observations, and had to rely on indirect means to derive a food consumption figure.

It is clear that a tiger can eat a prodigious amount during the course of a night, as the weights of freshly killed animals before and after a meal showed. For example, in one night two tigresses devoured 89 pounds of meat—about 44½ pounds each—from a cow. In a similar situation, a tigress with four small cubs ate 85 pounds from a gaur. Although an adult tiger, weighing 250 to 400 pounds, can consume 40 to 60 pounds of meat at a time, this gives little indication of the cat's need on a long-term basis. The tiger is adapted to a feast or famine regime—several days sometimes pass without it being able to secure food. Although the animal has a seemingly unbeatable array of weapons with which to capture its prey—acute senses, tremendous strength, and formidable claws and teeth—the wild hoofed animals also have their defenses, particularly a good sense of smell and great speed. As a result, the tiger must work hard for its meals,

Large and heavy gaur are form of wild cattle. Their formidable horns and size—bulls may weigh a ton—can often deter tigers from attack.

Sambar, largest Indian deer species, is favored tiger prey throughout that country. Primarily nocturnal, it stays in dense forest in daytime.

An adult tiger that weighs from 250 to 400 pounds can eat 40 to 60 pounds of meat at one meal. Often it has had to roam for miles before finding prey.

roaming many miles nightly and making numerous unsuccessful attempts before finally surprising a potential meal.

A typical hunt went as follows: at dusk (5:57 P.M.), a male tiger strode out of the forest and angled over a stretch of meadow into a tree-fringed ravine. A langur monkey barked in alarm on seeing him. The tiger advanced about 300 feet up the ravine, entered a patch of forest, and moved to the edge of a piece of grassland on which about 60 chital and barasingha grazed. From 6:12 to 6:20 P.M. he stalked up a shallow ravine that wound partly across the meadow, attempting to get close to the deer. Suddenly a chital barked and so did a barasingha; both had sensed the hidden tiger. Another barasingha barked back hoarsely, and the whole herd fled. They stopped abruptly, then stood and watched the cat as it emerged from the ravine 150 feet away, secure from attack at that distance. The tiger emitted several muffled roars, as the cats often do after an unsuccessful stalk, and departed.

Tigers in zoos are kept in good condition on about 8 to 12 pounds of meat per day. In the wild, where they are more active, 12 to 15 pounds of meat per day are probably sufficient. At this rate of consumption a tiger needs 4,380 to 5,475 pounds of meat per year. However, parts of each animal are inedible, mainly the stomach contents and most of the bones. These comprise about 30 per cent of the total weight of a deer or other large prey. If the tiger consumes some 70 per cent of the total weight of its victim, it must kill about 6,257 to 7,821 pounds of prey per year to sustain itself. This amount represents a minimum and presumes that the tiger devours all edible parts of the carcass. Unless disturbed by man, this is usually the case, for the tiger camps, so to speak, by the remains—for days if necessary—until the last rotten scrap of meat has been eaten.

The patterns of black stripes on the faces of the cats, particularly those directly above each eye, are so distinctive that it was possible for me to recognize every tiger in the study area individually. A male tiger and a tigress resided there permanently. Two other tigresses used the area sporadically, as did at least seven transients—wandering adult tigers that stayed a few days to a few weeks and then disappeared. The amount of prey killed by these nine transient animals was probably equal to that taken by 2 to 2½ resident adults.

There were also five cubs, four belonging to one tigress and one to another, each of which probably needed about half as much meat as an adult. Thus the area supported the equivalent of 6½ to 7 adult tigers, which required a total of 40,670 to 54,747 pounds of prey during the year. The food requirement of these tigers was roughly similar to the 50,625 pounds computed as the total mortality of the main prey species. Illegal killing of wildlife by the local peoples also accounted for a few pounds.

What, then, was the actual effect of the predation on the wildlife populations? All evidence indicates that the tiger was the main factor limiting the growth of the deer and gaur populations during 1964, and that my small study area contained almost as many tigers as the prey could support. But in spite of the heavy predator pressure, all species except the barasingha remained stable or increased slightly in number. If extensive hunting by man had been added to the existing natural predation that year, the prey would have been unable to maintain its numbers. Judging by the frequency with which I found old snares and other signs of poaching, the villagers did a great deal of hunting in the park in 1963 and earlier. This poaching, plus the killing by tigers, was undoubtedly the cause for the general decline of the deer. Interestingly, gaur are not regularly poached, primarily because of their resemblance to sacred cows, and they have been increasing steadily in recent years in spite of the numerous tigers in the vicinity.

The tigers in the area subsisted for the most part on wildlife, although they also took some 6,800 pounds of livestock. In other parts of the park, where deer were scarce, the cats fed almost wholly on cattle and buffalo. Without the easily available livestock as prey, the one tigress with four cubs in the study area might not have been able to secure enough food during the 1½ to 2 years that it takes to raise a young from birth until it is large enough to hunt consistently on its own. Tigresses are rarely accompanied by more than two cubs. The others apparently die from starvation and possibly disease or other causes. Thus the livestock is an important buffer that maintains the tigers at an artificially high level—a level the

wildlife alone could not support. The sudden removal of all livestock would for a time raise the predator pressure on the wildlife, possibly preventing its increase. It might also cause a movement of tigers out of the area.

Another important concept needs consideration. Errington stated that "regardless of the countless individuals or the large percentage of populations that may annually be killed by predators, predation looks ineffective as a limiting factor to the extent that intraspecific self-limiting mechanisms basically determine population levels maintained by the prey." That is, populations of hoofed animals will tend to increase in size *in spite of* predation, if they are large and healthy, until their ultimate level is determined by such factors as disease and availability of food. Individuals that fail to die from one cause will merely succumb to another.

The tiger population may also be self-limiting. Intolerance between tigers that meet on the trail or share a kill, as they occasionally do, possibly spaces out individuals regardless of the abundance of prey. When, for instance, almost all wildlife at Kanha was concentrated into a few square miles near the waterholes during the hot season, the number of tigers in the area did not increase. It is likely, too, that when a predator population passes its optimum level, reproduction declines or stops, as may have been the case with the wolves on Isle Royale. Females may abandon their young, and they may have smaller litters than usual, as has been reported in the lion. These are all means of population control.

The interrelationship between a predator and its prey is exceedingly complex, and a brief study can do little more than hint at answers. Wildlife populations are never static. Not only are there natural dynamic changes in the populations, but such factors as poaching by man and grazing by livestock contribute to the instability. Conditions in Kanha Park may well have changed drastically since 1964, and my conclusions from there may not be applicable to other areas. But studies such as these refute the popular formula of predation that can be written somewhat facetiously as Tiger + Deer = Tiger. This oversimplification can be replaced with the concept that the large predators in themselves rarely, if ever, have a long-lasting, serious effect on a healthy prey population.

A tiger must kill up to 7,800 pounds of prey every year, at a minimum, in order to sustain itself. However, the current study indicates that, even so, these large predators do not have any long-lasting effect on a healthy prey population.

DESCENDING THE ANDROS REEF

The profusion of life and color on an underwater cliff

by C. LAVETT SMITH   Photographs by EDWARD C. McCOY

Along the eastern margin of Andros Island in the Bahamas, a flourishing coral barrier reef crowns the summit of one of the most spectacular escarpments on this planet. Here the Great Bahama Bank meets the open waters of the trench called the Tongue of the Ocean in a sheer vertical wall that plunges downward more than 4,000 feet to the bottom. Many mysteries of the coral reef remain unsolved, and the vertical wall, itself the product of past coral growth, remains virtually unexplored.

The remarkable photographs on the following pages record some of the forms of life that exist on the Andros Barrier Reef and particularly on the Andros underwater cliff. They were taken by Edward C. McCoy, an ensign in the U.S. Navy and a Scuba diver, at depths as great as 240 feet.

While Mr. McCoy is an underwater photographer of rare talent, he is not the first to have been fascinated by coral reefs. The almost incredible profusion of attached and free-living organisms, the bizarre shapes and sometimes brilliant colors of the reef dwellers, as well as their complicated interrelationships, have long captivated the imagination of all naturalists. Coral reefs are among the most complex and least understood of all organism communities. Controversy still rages over the details of their formation and over such fundamental problems as the mode of nutrition of the coral polyps themselves.

In general, reef-building corals are limited to the warmer parts of the oceans, and flourishing reefs can exist only where the surface temperature never falls below 70 degrees Fahrenheit. Corals can tolerate neither fresh water nor excessive silt, and many species grow best where there is considerable wave action. The bodies of most reef-building corals contain single-celled plants, and in the presence of light, these plant cells manufacture food substances utilized by the corals that shelter them. For this reason, corals are most prolific where there is intense light, and since they must be attached to the bottom they can flourish only in seas that are warm and shallow.

The configuration of the coral reefs of the northern Bahamas depends closely on that of the marine limestone rocks that underlie the islands. The Bahamas are located on shallow banks—broad, nearly flat plateaus with their surfaces less than thirty feet (sometimes less than twenty) below mean sea level. During the Ice Age, when the sea level was lower than it is now, these banks were exposed. Wind-blown sediments piled up along their edges and later solidified, forming the rocky base of the present-day Bahama Islands. As the sea level rose after the last glacial periods, the coral reefs started to grow again and the waves began to cut away the vulnerable parts of the shoreline. Today, the islands are still being carved away in some places and built up in others, hence their outline is constantly changing.

Each of the submerged Bahama Banks is different and has its own particular "personality," but there is a general pattern common to them all. The central part of each bank is nearly flat. The large islands lie along the eastern and northern edges of these flat areas, although occasionally there may be low islands or rocks along the western and southern boundaries.

An outer shelf surrounds the flat part of the bank; this shelf is usually less than one mile wide

Flexible branching corals are commonly seen on the wall, this one at about 200 feet. Violet fish, a blackcap basslet, swims behind the strands.

Above, covered with small sponges, algae, and gorgonian corals, a sponge four feet tall is seen on the middle reef at about 100 feet.

Below, at depths of 200 feet, green and brown algae and encrusting sponges create a gay mosaic of color on the face of the wall.

Above, a fairy basslet, found in abundance on Andros Reef, swims in front of a lettuce coral on which grows an orange encrusting sponge.

Below, resembling the udder of a cow, a delicate, cream-colored sponge is found at about 200 feet, hanging from the underside of a ledge.

Without the artificial light of the flash this spectacularly yellow sponge would look gray.

A magnificent coral "tree," with flexible stems that wave in the current, is seen at 175 feet.

A red sponge has encrusted a mitten-shaped clam that is attached to a gorgonian coral.

Disk coral, two yards across, is seen at 240 feet. Each white dot is a single polyp cup.

and slopes gently seaward to anywhere from 60 to 150 feet under the surface. Then it plunges almost vertically to the depths of the ocean. The steepness of this vertical wall can be appreciated when we realize that in some places depths of 12,000 feet are found within two miles of shore. The sheer wall below the Andros Reef is perhaps the most studied of all these cliffs, and it offers some of the most magnificent underwater scenery in the world.

The Andros Reef has many faces. To get out to the drop-off from the shore of Andros Island a diver must pass over several tempting and well-defined zones, each with its own spectacular assemblage of plants, corals, fishes, and other organisms.

At various points along the shore, coralline algae have built a narrow terrace. Beyond this terrace the rocky bottom drops to perhaps six to ten feet, then levels off, forming a moat between the island and the reef. Parts of the moat's bottom are sandy with dense beds of turtle grass; others are rocky with occasional coral and sea fan colonies and a thick carpet of various kinds of algae. The moat ranges from one-half mile to three miles wide; at its outer edge, the water becomes shallower and the coral colonies more abundant. This is the back of the barrier reef. Globose and lettuce corals thrive here. Sea fans form thick gardens and colonies of stinging coral resembling miniature medieval castles dot the underwater landscape. Here and there a small rocky islet punctuates the line of breakers.

On the seaward side, profuse stands of elkhorn coral grow, receiving the direct attack of the waves, and rising to within a foot or so of the low-tide level. Dislodged, treelike elkhorn corals sometimes stick out of the water like the ribs of a wrecked ship. Some are fifteen to twenty feet high and more than two feet thick at the base.

Seaward of the elkhorn barrier, the bottom slopes steeply downward. This outer slope, or "middle reef," extends from about the 30-foot level to about 80 to 120 feet at the drop-off. Globose brain corals and dead colonies fallen from the reef above predominate in this region, and sea whips and other soft corals, such as the flexible gorgonian corals on page 39, are abundant. Here one finds occasional large sponges anchored to the coral mass, such as the one on page 40.

At the drop-off, the fauna changes abruptly. Many species of fishes new to science have been described from this level since scientific collectors started using Scuba in their field work. Sponges predominate at this depth, and many of them have an eerie, florescent appearance and develop weird, surrealistic shapes.

Beginning at a depth of about 140 feet and clinging to the overhangs of ledges on the wall, a diver may see fragile, cream-colored sponges like the one on page 41. If brought up to shallower waters where there is less pressure, they will disintegrate, and when handled with bare hands, their fine spicules pierce the skin as the fibers of glass wool will do. Down at 175 feet, where the water temperature has been recorded as only 2 degrees less than that of the surface, several kinds of coral grow. For example, as shown on page 42, one may find large, platelike corals some six to eight feet in diameter. The polyps are arranged in concentric circles like the rings of a tree.

At these depths, everything seems to be an intense blue that contrasts sharply with the greens of the moat and reef area. Only the artificial light of the photofloods and flash bulbs brings out the reds, yellows, purples, and greens. The brilliant purple of the fairy basslet on page 41 looks blue until seen in artificial light. Fish that are actually red have a translucent appearance here, because the long-wavelength reds and yellows have been filtered out by the water.

Even divers with years of experience on shallow reefs will find a new world on the vertical face of this great cliff. Intimately allied to the coral reefs above, it stands as a distinct subdivision of the Bahamian marine environment. Some of the organisms that live here also live in shallower water, but others reach their upper limit at the edge of the drop-off. As on shallow reefs, the surface features of the vertical wall are formed by living plants and animals—some building the structure, while others attack it.

Modern diving and photographic equipment make it possible for scientists to study all these organisms where they live, or once lived, instead of depending on random samples pulled up by clumsy, surface-operated equipment. Yet with all of our modern diving techniques, we have only obtained a glimpse, and a partial one at that. Deeper dives will be possible in the next few years, and gradually we will begin to understand the unique features of this strange and beautiful underwater wonderland.

Two nearest galaxies, Large and Small Magellanic Clouds, and bright star Achernar (top right) are near south celestial pole. Observation of Cepheid variable stars in Small Ma gellanic Cloud led to discovery of period-luminosity law

SKY REPORTER

Three variable star types are visible in the October sky

By Thomas D. Nicholson

A good many amateur astronomers continue to make an important contribution to astronomical knowledge through the observation of a peculiar, but highly significant, group of stars—those that periodically undergo changes in brightness. These stars are known as variable stars. Although some 10,000 such stars are known within our Galaxy, they comprise a relatively small population among all those we observe. It has been estimated that perhaps only one in a million stars may be variable. Yet these stars have assumed an importance in astronomy completely out of proportion to their relative abundance. They have provided astronomers with one of their most powerful tools for measuring distances to remote objects in the universe; they are valuable indicators to different populations of stars that seem to occupy different parts of stellar systems; and they have helped to bridge some of the gaps in our knowledge of stellar evolution. At the same time, they present some of the most perplexing problems remaining in astronomy.

This month's sky offers the opportunity to observe three famous variable stars, among the first such stars to be recognized. Each of them is quite different from the other, and each is considered to be a prototype for a large number of similar stars. The three stars are Mira, in the constellation Cetus; Algol, in the constellation Perseus; and Delta, in the constellation Cepheus.

It surprises even astronomers to realize that the earliest known reference to a star that varies in brightness

dates only to the year 1596, when the Dutch astronomer Fabricius observed a star in the constellation Cetus that, in August of that year, was near second magnitude, but that faded to invisibility by October. Christened Mira (the Wonderful) by Hevelius, the periodicity of its light changes was not firmly established until 1660. There is a suggestion that the variability of another star, Algol, might have been observed by Arabic astronomers at the earlier epoch in which that star received its name (it is presumed to derive from the Arabic *al Ghul*, or the "demon star"), but no clear reference to stellar variability predates the observation of Fabricius. This is especially surprising because the star catalogue of Hipparchus and Ptolemy, included as part of Ptolemy's *Almagest*, classified the brightness of hundreds of stars in the magnitude scale devised by Hipparchus. Further, it is reported by contemporary Latin authors that one of Hipparchus' aims in compiling a star catalogue was to determine whether there was any variation in stellar brightness. It seems difficult to understand how the variability of stars such as Mira and Algol (both of which change enough to be easily discernible to the unaided eye) could have escaped the attention of Hipparchus and Ptolemy, or of the many observers who followed them—armed with their catalogue—through the centuries until 1596. Yet the record prior to that year is blank.

The variations of brightness in Algol were first brought to the attention of astronomers by the Italian G. Montonari, in 1669, but John Goodricke, of England, is credited with first establishing the period and nature of its variability more than a century later, in 1783. It was also Goodricke, in the following year, who discovered the changing brightness of the star Delta, in Cepheus, the first known number in its class of variable stars, subsequently known as Cepheids, which were to become enormously significant in the twentieth century. Investigations that followed confirmed that each star was indeed a distinctively different type of object, and each has since given its name to the class of stars that is representative of its type.

Mira Ceti, Long-period Variable

The star known as Mira Ceti is located in the northeastern part of Cetus, the Whale, about 6 degrees to the south and east of the star Alpha in Pisces (sometimes known as "the Knot"). Over a period of time averaging about eleven months, Mira undergoes major changes in brightness. For about three months, it is bright enough to be seen by the unaided eye, becoming—at maximum brightness—a star of 3rd or 4th magnitude, sometimes even 2nd magnitude. For the remaining eight months of its period, it dims to a minimum of 8th or 9th magnitude, visible only with telescopes. Its light curve shows that it is subject to rather large changes in the period from one maximum to another, and that its maximum and minimum brightness may vary by more than a magnitude from one period to the next. Most remarkable is the range in total light output indicated by its light changes. From minimum to maximum Mira Ceti may increase the energy it radiates by about 1,400 times. Mira has actually been known to brighten to magnitude + 1.2.

Mira is now recognized as a representative of nearly 3,700 similar stars known as Mira-type long-period variables. These are all red giant or supergiant stars, varying in brightness in a regular way for periods ranging from 80 to 1,000 days. In general, the longer their period, the less regular are the periods and amplitudes of the light variations. The absolute magnitudes of these stars range from about +2 to −2 (the absolute magnitude of the sun, by comparison, is about +4.6), and the average range from minimum to maximum brightness is about 2.5 magnitudes.

Algol, Eclipsing Binary

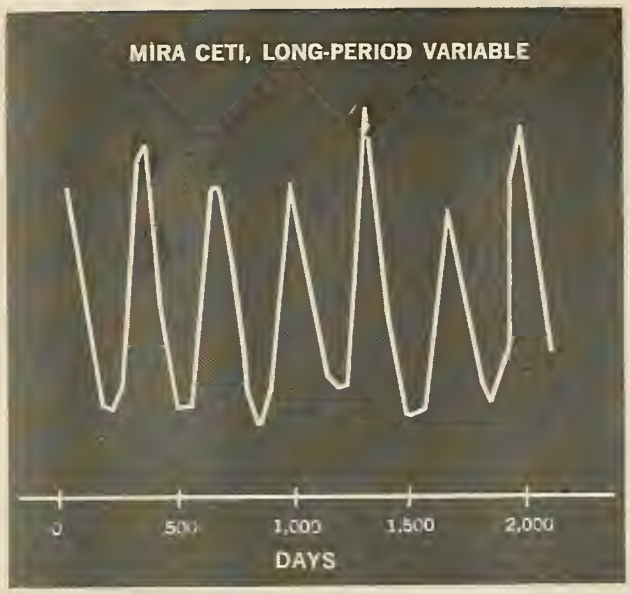
The second variable star discovered, Algol, is found in the constellation Perseus, about midway between, and some distance south of, Mirfak (Alpha Persei) and Almach (Gamma Andromedae), almost forming an isosceles triangle with the latter two stars. For nearly two and a half days, Algol remains at a constant brightness, + 2.3 (except for the slight change described below). Then its brightness begins to decrease sharply to a minimum of magnitude +3.5 in about five hours, followed by an equally sharp and rapid rise to its normal brightness again. The peculiar nature of this change suggested to Goodricke that it might be the effect of a dark star periodically passing in front of Algol and obscuring part of it from our view. In 1889 a German astronomer, H. Vogel, found evidence in the spectrum of Algol that it was indeed a binary star, even though only one star was visible telescopically. Then, in 1910, Joel Stebbins, of the University of Illinois Observatory, found that Algol's light curve had a secondary minimum, only 0.06 magnitude, at the middle of its constancy. This dispelled the notion that the obscuring companion was dark, for its disappearance behind the brighter component was what produced the secondary dip in brightness.

Algol, therefore, is not truly a variable star. It is, instead, an eclipsing binary star, in which the variations in observed brightness are produced by periodic eclipses of one star by another. A great many similar stars are now known, each of which have light curves similar, in their general features, to Algol's. While not variables, these eclipsing binary stars are most significant in their own right, for careful observations of their period, amplitude, and velocities (from their spectra) can yield the distances to the stars, their masses, and the sizes of the component stars involved. Indeed, such stars are the only ones for which accurate masses and sizes can be obtained.

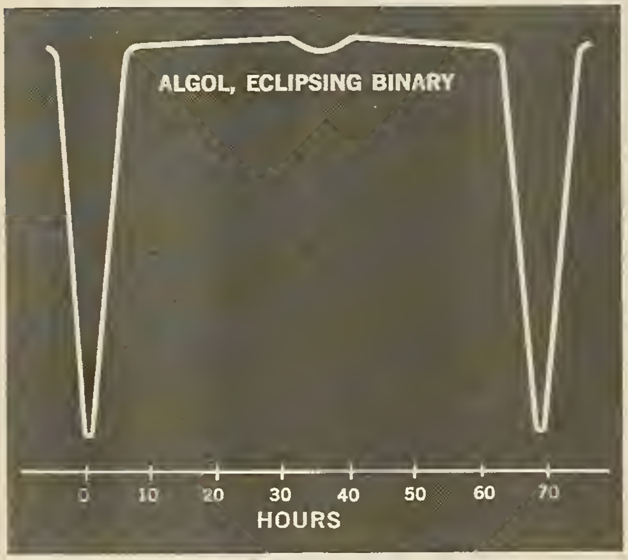
Delta Cephei, Short-period Variable

The third famous variable in our autumn sky is Delta, in Cepheus. Located in the far northern sky, Delta Cephei is in the southeastern part of Cepheus, about midway and a little below a line between the western star of Cassiopeia's "Chair" (Caph) and the brightest star in Cepheus, Alderamin. Delta Cephei, about 4th magnitude at its brightest, is just a few degrees to the east of the 3rd magnitude star Zeta Cephei. The principal features of its variability were observed by John Goodricke. In a period of 5.4 days, its brightness goes from a maximum of 4.1 to a minimum of 5.2. The light curve of Delta Cephei is characterized by its short period, the regularity of the period and the brightness at maximum and minimum, and the nature of the curve—a sharp rise to maximum followed by a relatively slow decline to minimum.

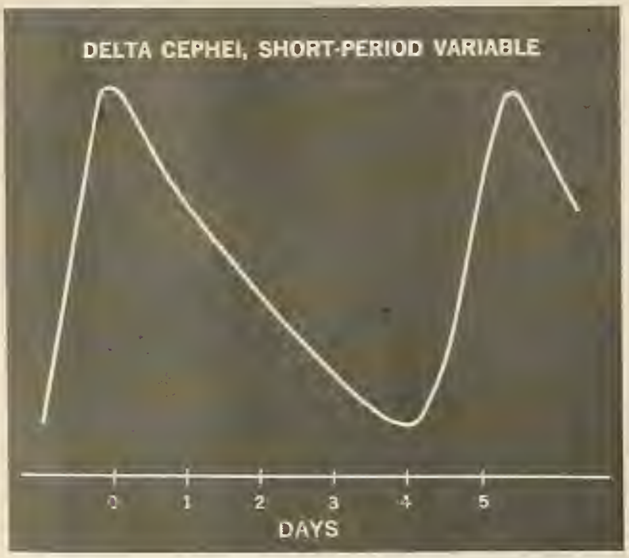
Subsequently, a great many stars have been discovered with light variations similar to those of Delta



Large brightness changes and irregularities in period and amplitude are quite marked in long-period variable stars.



Light curve of Algol—not a true variable star—reveals the presence of two stars experiencing periodic eclipses.



Regularity of changes in brightness, with rapid rise and slow decline, mark the light changes of Cepheid-type stars.

Cephei. These are known as Cepheid variable stars. Their periods range from 3 to 50 days, the amplitude of the variation ranges from 0.1 to 2 magnitudes, and their absolute magnitudes from —1.5 to —5. They are all yellow or red supergiant stars. Some 600 such stars are known in the Galaxy. In addition, many of them have been observed in other galaxies, since they are among the brightest of stars and can be observed at very great distances. The Cepheid variable stars are responsible for one of the most exciting chapters in the history of astronomy.

In the year 1912, an astronomer at the Harvard College Observatory, Miss Henrietta Leavitt, identified 25 Cepheid-type variable stars in photographs of the Small Magellanic Cloud (*shown on page 44*). She discovered that there was a simple relationship between their apparent magnitudes and the period of their variability, such that the stars of longer period were observed to be brighter. Since all of the stars were at about the same distance—although their exact distance was not known, they were all in the same star cloud—this suggested that there must be a relationship between the absolute magnitude and the period of variability for these short-period variable stars. In the years following, this relationship, known as the period-luminosity law, was found, and became a powerful tool for measuring the distance to Cepheid variable stars and, therefore, the star systems in which they were located. The complete story of the discovery of this law, and its modifications as other types of short-period variable stars—differing somewhat from the Cepheids—were identified, is too complex to go into here. But once the nature of a short-period variable star is established, the absolute magnitude of the star can be obtained from an observation of the period of its variability. The distance to the star can then be established from the difference between its apparent magnitude and its absolute magnitude, because the effect of distance in dimming its light is known.

Apart from the changes in its brightness and the characteristic features of its light curve, a variable star demonstrates other interesting features. During the period of its light curve, the spectral classification of the star and the temperature of its surface change. There is also ample evidence that the star expands and contracts as it dims and brightens, but in a relation to its light changes that is sometimes rather peculiar. The conclusion is inescapable that the changes in brightness of a variable star are produced by some mechanism that causes changes in its internal structure; it is not true of Algol-type variables, of course, in which the light changes result from external factors (the eclipsing of one star by another). It was once thought that eclipses by another star might possibly explain all stellar variability. But the differences in the light curves between eclipsing binary stars and true variables (*see left*) are too striking, and other characteristics of intrinsically variable stars too obvious, to support such a simple notion. Much has yet to be learned about variable stars, but it will undoubtedly be worth the effort to explore them further, as many amateur astronomers do.

Dr. Nicholson, the regular author of this column, is also Chairman of the American Museum-Hayden Planetarium.

THE SKY IN OCTOBER

Last Quarter	October 7,	3:08 A.M., EST
New Moon	October 13,	10:52 P.M., EST
First Quarter	October 21,	12:34 A.M., EST
Full Moon	October 29,	5:00 A.M., EST

TIMETABLE

October 1	10:00 P.M.
October 15	9:00 P.M.
October 31	8:00 P.M.

(Local Mean Time)

October 8-9: Jupiter, by now, has moved into prominence in the morning sky. It rises about midnight and is high toward the south by dawn, magnitude −1.7. On the 8th, it rises after the moon and follows it across the sky; on the 9th, it rises first and precedes the moon.

October 10-11: Mars, some distance to the east of Jupiter and much fainter, magnitude + 1.8, is also becoming easier to see in the morning sky. It may be found on the mornings of the 10th and 11th, low in the east several hours before sunrise, near the bright star Regulus, in Leo. On the morning of the 10th, the late crescent moon rises just before Regulus and Mars, and moves up in the eastern sky to the right and above the pair until they disappear into the morning twilight.

October 15: Mercury, an evening star, is to the right (west) of the early crescent moon, but probably too close to the sun to be seen easily.

October 20: The Orionid meteors reach maximum this evening. This shower, a broad one visible for about a week before and after maximum, produces about 25 meteors per hour at maximum.

October 25: Saturn, about magnitude + 1.0, is just above the rising moon in the eastern sky early this evening. Follow it as it moves to the right during the next several hours, and you can see the distance from the planet to the moon slowly increase.

October 26: Mercury is at greatest elongation (24°) east of the sun, but this is an unfavorable elongation. At sunset, the planet is about 10 degrees high and in the southwest; it sets in the late twilight.

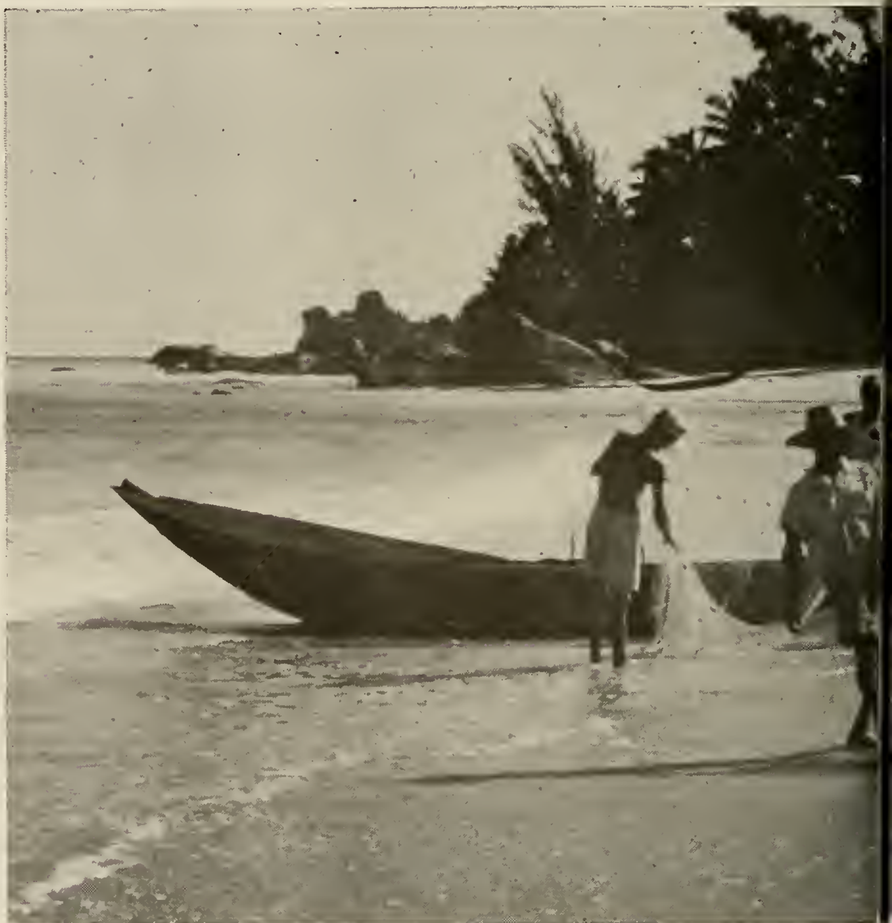
October 29: The full moon of tonight, the next following the harvest moon, is known as the hunter's moon. From about 2:53 A.M., EST, until moonset, the earth will partially cover the sun as seen from the moon's surface. This event, called a penumbral eclipse of the moon, will cause the moon to darken slightly, but no part of its surface, during the eclipse, will be completely blocked off from sunlight. The moon will appear darkest about 5:12 A.M., EST.

The Seychelles

Lying far outside the lanes of modern transportation, these remote tropical islands of the Indian Ocean are the home of a famous palm. First seen by Arabs, they were charted by the Portuguese, settled by the French.

Two outlying islets are seen from M largest island of the Seychelles gr

by Lynn Millar



Off the east coast of Africa, four degrees south of the Equator, are 92 reef-fringed, granitic islands known as the Seychelles, one of the loveliest and least frequented spots in the world today. Not only is there no commercial airport, but the islands lie out of the main trade routes and the traveler must depend on a ship from Bombay, India, or one from Mombasa, Kenya.

These islands stand on a kidney-shaped submarine plateau 10,000 square miles in area. Mahé, the site of the capital, Victoria, is the largest—seventeen miles long and five miles wide. Rising in the center of it is a giant massif—the almost 3,000-foot Morne Seychellois—that, with the peaks of Trois Frères, forms a backdrop to the port of Victoria.

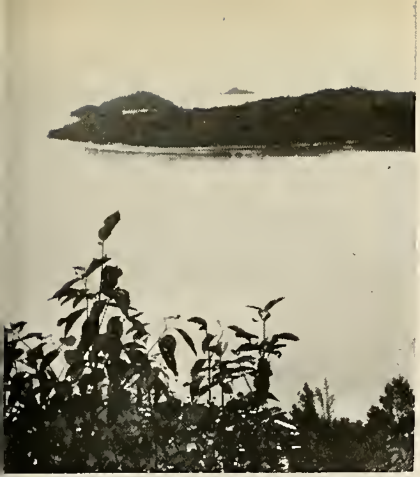
According to Seychelles annals it is thought that the Arabs in their dhows were the first to see the islands. But it is fairly certain that the Portuguese visited the group during the sixteenth century and charted them. They named the islands the Seven Sisters, a name by which they were known until the French rediscovered them in the mid-eighteenth century.

There were no indigenous inhabitants, nor did the Portuguese attempt to settle there. During the eighteenth century the islands were used as hide-outs for pirates. In the mid-eighteenth century Captain Corneille Morphey in the frigate *Le Cerf* was sent by the French to ward off the British, who were thought to be looking for islands to use as naval bases. In 1756 a "Stone of Possession" was set up at Mahé, and Captain Morphey named the group after Moreau de Séchelles, at that time finance minister under Louis XV. The French sent colonists, soldiers, and slaves and started spice plantations, which flourished. During the Napoleonic Wars the British captured the Seychelles, and permanent colonization began. In 1903 they became a crown colony under British rule.

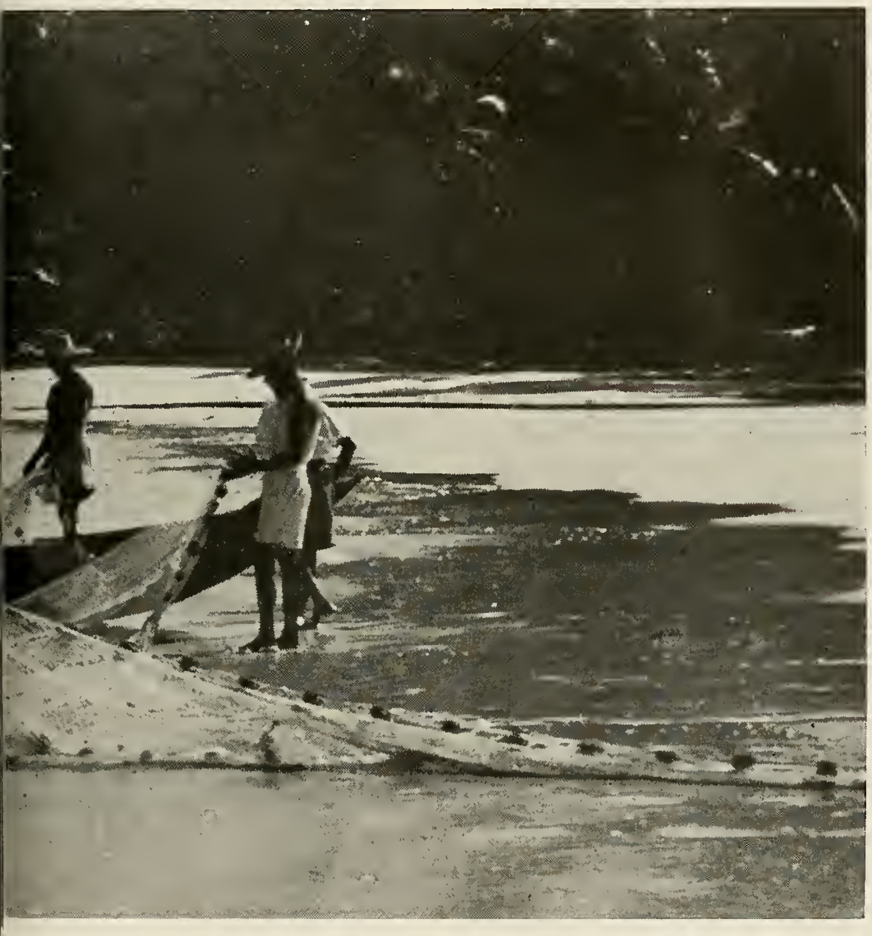
Today about 90 per cent of the archipelago's 46,000 inhabitants are the descendants of the African slaves imported during the eighteenth and early nineteenth centuries from Madagascar and Mozambique. The rest of the population is a conglomeration of French, Indian, British, and Chinese.

The atmosphere of the Seychelles is African, although the Seychellois of today have a nineteenth-century French culture—a holdover from the French occupation from 1756 to the Treaty of Paris in 1814, when the islands were ceded to the British. Although English is taught in the schools, the natives speak French Creole, and the population is about 95 per cent Roman Catholic.

Perhaps the Seychelles more than any other islands deserve to be con-



Fishermen, using pirogue and nets, are on one of numerous beaches on Mahé.



sidered true palm islands. The Seychelles can boast what may be the most famous palm in the world, the coco-de-mer, or *Lodoicea maldivica*, the double-coconut palm, which grows indigenously in the Valleé de Mai on Praslin, one of the islands of the archipelago. Other islands of the group grow five or more kinds of indigenous palms. The coco-de-mer is an unusual species. These palms sometimes live 600 years, and seem to be associated with an extremely rare bird, the black Praslin parrot, which nests in these towering trees and haunts the sands of Praslin Island. A tall, slender palm, which may reach a height of 120 feet, the coco-de-mer has huge, fan-shaped, rustling fronds and a bilobed fruit weighing from 20 to 40 pounds that takes 10 years to ripen. The fruit was supposed to have been a product of the sea, as it was first seen washed up on the shores of the Malabar Coast of India—thus its name, coco-de-mer.

To the Seychellois the palm is a staple of their life. It provides fruit and drink—the coconut water, the "meat," the extracted coconut cream, and the so-called millionaire's salad or king's cabbage, made from the heart bud extracted from among the leaf fronds at the top of the tree. This is a rare dish since it can only be obtained by killing the tree.

The economic importance of the palm to the Seychellois is basic. Shipments of coconut represent about 75 per cent of the total exports of the islands. Copra is the dried meat of the coconut, and the copra from the Seychelles reportedly receives a premium above world market prices.

When one approaches Mahé, the island appears to be almost shrouded with coconut palms, which grow about halfway up the steep slopes of the island. On close inspection it is clear that the palm is planted wherever there is a pocket of soil in the granitic rocks to support it. The houses of the natives are often supported on coconut trunks; many are walled and thatched with coconut fronds. Fishing nets and ropes, mats, and brushes are made from fibers extracted from the husk of the nut. Lime and bricks are burned with coconut fuel.

Almost everyone in the Seychelles fishes either for livelihood or for sport. A common sight is a Seychellois sculling along the waters of a lagoon in his pirogue—a narrow, sharply pointed craft—fish hunting with a spear. In the coral lagoons all around the two main islands of Mahé and Praslin, traps made of coconut fronds are placed on the lagoon bottom, baited with crab or other shellfish. The butterfly-shaped traps are called *casiers* in Creole. During the months of November through February the local Seychellois of Mahé trap and hawk crayfish or *homards* (lobster). The commonest and most important of the shoaling fishes are the blue and green mackerel.

As an attraction for tourists there is also big-game fishing, ranging from barracuda, shark, tuna, kingfish, sailfish, marlin, and even the devil ray. The best months for sea fishing are from February to May when the southeast monsoon is not blowing. But generally there is little variation in the island's climate.

The view approaching Victoria, capital of the islands, is particularly entrancing by sea. Two long jetties protrude into calm shallow water, and onshore white buildings show

Of great importance to the economy of the Seychelles are palm groves such as one above; from them comes copra, the island's chief export. Natives, below, crack coconuts, which are then left to dry in the intense tropical heat.

through a screen of trees. The massif of Trois Frères rises up behind the town, and there is an atmosphere of calm and remoteness that makes the scene appear untouched by contemporary civilization. Much of Victoria remains as it was when it was named for Queen Victoria in 1841, and association with the queen also influenced the naming of the streets. In 1903 the Victoria Memorial Clock Tower, still the town's most outstanding landmark, was erected; it is a smaller copy of the clock at Westminster. Mahé's narrow, winding streets rise upward from the port. The mackerel catch is brought in on the jetties, where it is strung up on bamboo poles and carried to the local market on the shoulders of the natives. The architecture is French colonial with overhanging balconies, the buildings not unlike those of the French Quarter of New Orleans. Again the street names recall the island's history; for example, Rue Royale was the town's fashionable center 150 years ago.

In the town a tourist can buy almost anything from fishing gear to hats. The natives make all kinds of hats of different colors and shapes, which are sold in a shop in Victoria, and also are worn by the natives. These hats, so characteristic of the Seychelles, are made from raffia, screw pine, and coco-de-mer. Some with broad straw brims are designed after the ones that were worn by Lord Nelson's sailors.

There is a sleepy, forgotten quality about the atmosphere of Victoria, and only at the local fruit and vegetable market on a side street does the business of port life become apparent. Here a visitor can get an idea of the variety of racial types that live in harmony on the islands.

From Port Victoria to the northeast of Mahé, a beautiful marine drive encircles the island. In almost every cove there are bathing beaches, or one sees fishermen in broad straw hats mending nets from sailboats or the slender pirogues, or trailing their nets beyond the outlying reefs.

Throughout the islands, breadfruit grows wild on large leafy trees and is the substitute for potatoes, which do not grow on the islands. It is locally said that he who eats breadfruit is destined to return to the Seychelles. Perhaps that is enough of an enticement to try.

Above is a typical Seychellois, a descendant of African slaves imported during the eighteenth and nineteenth centuries. The market, above, and street, below, in Victoria, are colorful business centers of the sleepy islands' capital.

Time and Space in the Life of the Bee

Complex navigation systems depend on the precise use of spatial and temporal clues

by MAX RENNER

The knowledge that animal behavior is dependent on the time of day and the annual cycle of the seasons has been common since ancient times, but until half a century ago these relations had hardly been subject to serious investigation. Behavioral changes paralleling the daily cycle of night and day or seasonal variations appeared too obvious—too close to personal experience—to arouse any special interest. Only when it was realized that behavioral rhythms and periodic physiological processes continue even under artificially constant conditions—for example, under continuous illumination—did this attitude change.

One of the first biologists to contribute in this direction was Charles Darwin. He described how earthworms retain, for about a week, the habit of leaving their burrows only at night, even if they are kept in constant darkness. That bees also have a way of telling time was discovered in 1905 by the Swiss physiologist August Forel. Every morning at the same hour, Forel had breakfast with his family on the garden terrace. One morning the honey and marmalade on the table were discovered by bees; these uninvited guests then appeared regularly, day after day, and in increasing hordes. Finally, breakfast on the terrace became impossible and the meal had to be moved indoors. But the next day, at breakfast time, Forel glanced through the window and was astonished to observe that the bees had turned up at the usual time and were searching for food around the now-empty table. Since there were no breakfast remnants from the previous morning to attract the bees, the only plausible explanation for their reappearance was that "bees possess a sense of time."

In the October, 1959, issue of NATURAL HISTORY, I described experiments aimed at solving the mystery of the bee's clock. One question warranted particular interest. In order to orient themselves to time, do bees connect a daily, recurring event—say a specific position of the sun—with the experience of a freely available food source? Or are they, on the other hand, able to orient themselves by an "internal clock," independent of such external periodicities?

Early in the course of these investigations it was found that bees were on time even when kept in a continually illuminated and temperature-constant room. In such rooms, however, environmental clues to a 24-hour periodicity could not be wholly eliminated. Bees might, for example, respond to recurring changes in atmospheric pressure.

An unequivocal answer could result only after a long-distance displacement experiment had been carried out. If, for example, bees were trained in Paris to feed at a specific time, then flown to New York overnight and tested there, they should search for food some 5 hours after the 24-hour period—that is, 29 hours after their last feeding period—if they used outside clues for time orientation. On the other hand, if the bees abided solely by an internal clock independent of outside clues, they would search for food, as usual, 24 hours after the last feeding period, even after having been transported some 3,000 miles.

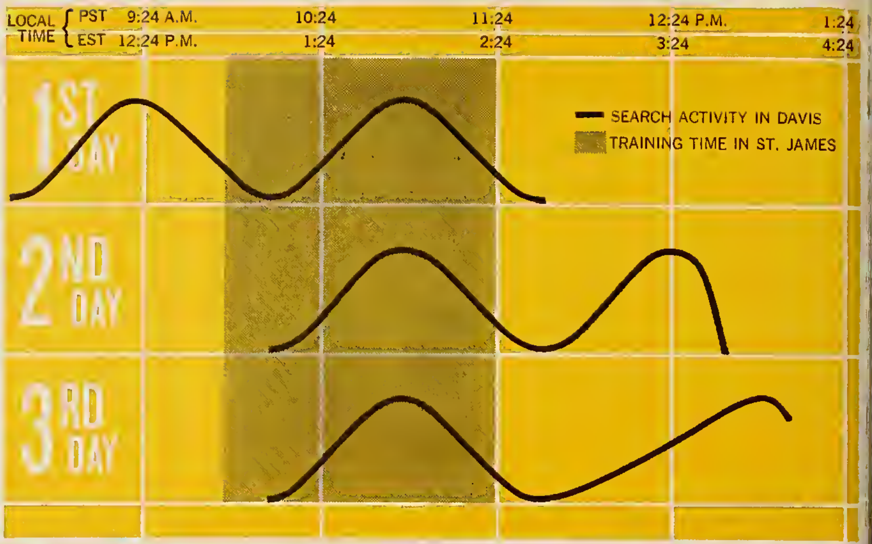
The results of the displacement experiment showed that the bees searched at their usual time, 24 hours after the last feeding period. The reverse experiment—training in New York and testing in Paris—had an analogous result, indicating that it was the internal clock that was functioning.

It should be pointed out that in both these experiments, light and temperature were held constant. The question of whether the same thing would occur in a natural environment remained unsolved. It could be answered by a displacement experiment in which training and testing took place in the open. The starting point this time was St. James, on Long Island, N.Y., and the target was Davis, in the Sacramento Valley of California. Some 40 foragers were trained in St. James to feed from 12:54 to 2:24 P.M., EST, then transported by air (in their hive) across the continent to Davis, where they were tested on three successive days.

The true local time difference between the two locations is three hours and fifteen minutes. The sun rises three and a quarter hours later in Davis than in St. James. If external factors play a role in time judgment under natural conditions, this would be made apparent by delayed searching activity. Should the bees, however, obey only their internal clocks, they would search for food as usual, 24 hours after their last training period; in this case, between 9:54 and 11:24 A.M., PST.

Some of the results of the experiment, in which observations were continued for three days, are shown on page 54. Normally on the test day there is only one peak on a graph of the search activity of bees trained to a specific time period. In Davis, however, two peaks occurred on each of the three observation days. On the first day, the first peak of search ac-

Curves show search frequency of bees displaced to Davis, Cal. Migration of peaks shows adjustment to local time.



tivity came shortly before the beginning of the 24-hour interval since the last training period, which was normal. But while, also normally, the frequency of search flights began a steady return to zero, a new rise, peaking one and one-half hours later, followed the descending count.

On the second day of observations both peaks occurred one and one-half hours later than on the first day. On the third day the position of the first peak remained steady, whereas the second appeared thirty minutes later. This second peak, therefore, occurred three and a half hours later than the first peak of the first day; at approximately the time, surprisingly enough, that search activity would begin if the bees had been trained in California for the period 12:54 to 2:24 P.M., local time.

How is this ambiguous result to be interpreted? Since the migration of the second activity peak corresponds almost exactly to the difference between the two local times, it must have been caused by external factors. The relatively minor displacement of the first peak, however, is undoubtedly attributable to the effect of internal factors.

Bees obviously possess two systems for measuring time: an endogenous system, functioning largely independently of external factors and tied relatively inflexibly to the 24-hour rhythm of internal conditions, and an exogenous system, dependent on the change from night to day. Both systems influence each other within certain limits. Thus the internal clock—never exact to the minute in any case—can always be synchronized with the time of day or set, under normal conditions, by the change of night and day.

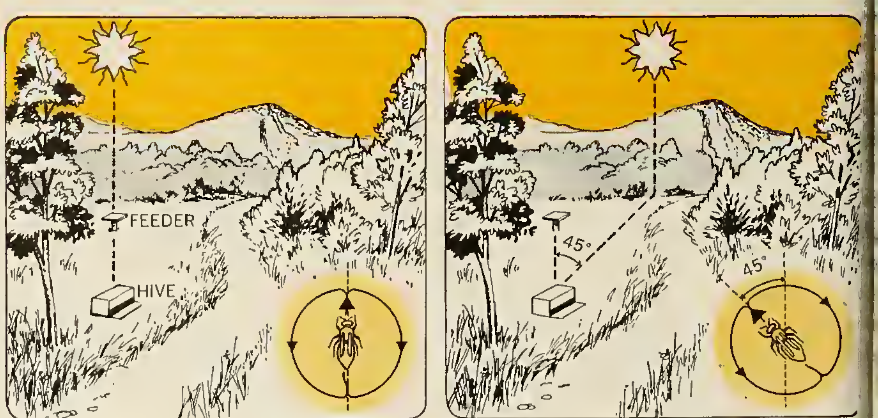
One may well ask about the biological significance of such a highly developed time sense. Most flowers produce nectar only at certain times of the day. If the collecting bees could learn when the particular blossoms on which they feed yield their nourishment, they would not have to leave the hive for inspection flights at times of poor yield.

The time sense is also important in the communication system of the bees. We know that, on their return to the hive, foragers that have discovered a rich food source alert other worker bees by dancing on the vertical comb inside the hive. Should the food be more than about 55 yards (50 meters) from the hive, recruits are alerted through the so-called waggle dance. The dancer moves in a figure-eight pattern that is a combination of semicircular and straight runs. The straight portion of the dance, the waggle run, during which the bee's abdomen waggles vigorously from side to side, brings the dancer back to the starting point of the previously traversed semicircle. The total number of figures completed in a given period of time indicates to the other bees the distance to the food source. The farther away the source, the slower the dance.

The precision of the message is striking, as Karl von Frisch's experiments have shown. Bees can pinpoint a location two-thirds of a mile from the hive within at least a 55-yard margin of error. The dance tempo at two-thirds of a mile amounts to 4.52 turns per 15 seconds, or to transpose the figure, one turn is completed in 3.32 seconds. If the food source is then moved 55 yards closer to the hive, a turn takes 3.27 seconds. Thus, bees must be able to keep time intervals of a few hundredths of a second.

If the foragers only gave information on distance, however, the message would be useless; the direction of the food supply must also be communicated. And, indeed, it is. The signpost is the waggle run.

A forager flying from the hive to the food source must necessarily keep at a certain angle to the sun's position. It is precisely this sun angle that is reproduced by the waggle dance on the vertical comb inside the hive. In this case the waggle run represents the leg of the angle that points to the food source. The other leg of the angle is based on a means of orientation that is available in



Straight run in waggle dance (inset) indicates food direction relative to sun. Vertical line, the "up" perceived by bees, represents sun's position.

ide the hive: the vertical upward irection perceived by the bees' re- eptors for gravitational force. It is n this line that the sun angle, now ie dance angle, is constructed.

A run straight up, for example, ieans that the food lies in the direc- on of the sun. A waggle run 45 egrees to the left of the vertical is iterpreted to mean that the goal is 5 degrees left of the direction of the in's position in the sky. This is iown in the lower diagram, page 54.

The sun serves as a means of in- icating direction. It is visible dur- ig the hours that the bee, as a day- tive animal, is moving outside the ive, and it remains visible to the traviolet-sensitive bee eye even hen it is behind clouds.

The apparent motion of the sun, owever, does somewhat limit its sefulness as an orientation marker. fixed reference system would be ore suitable. The bees, neverthe- ss, manage very well, despite the oving frame of reference. They iange the angle of their dance— hen repeatedly flying to the same al over relatively long periods—at e same rate that the angle of the n changes outside.

But there are bees that dance in- de the hive for long periods with- it flying outside. These are usually outs that have found a new home r the swarm, which will soon leave e hive. It is not essential for them keep flying back and forth be- een the hive and the new home, there is nothing to bring back. et it seems necessary for them to dicate the new domicile to many their fellow workers so that the ove can be made smoothly. Thus ey dance for hours without leaving e hive and with only brief rests. rprisingly, they also alter the gle of their dance at the same rate at the angle between the sun and eir new home changes; again the ise of time is obviously involved. ithout their internal clocks the bees ould not be able to correct that gle and give proper directions to ier bees by the waggle run.

We may ask if this clock is also portant outside the hive, for ghts to the food source. Can bees in open orient themselves by the sun ne in the same way that we are le to determine direction with the p of the sun and a watch?

To answer this, the following experiment (see below) was performed in June, 1952. In the evening, a colony was locked up in its hive; the next morning it was transported 20 miles to a place completely unknown to it. There the hive entrance was not opened until 1:00 P.M. A feeding station had been erected approximately 200 yards to the northwest. By 3:15 P.M., 30 marked foragers were visiting the feeding station.

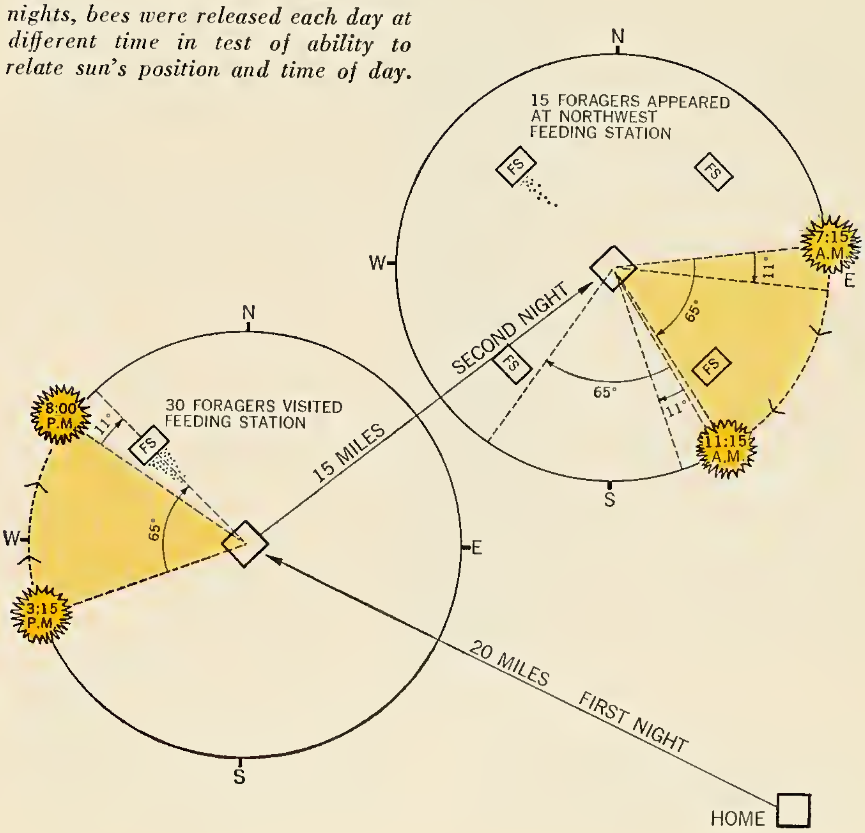
During the entire afternoon, while flying to the food source, the sun was on the left of the bees. In other words, the direction of the feeding station was to the right of the sun as it moved from west southwest to northwest. As darkness fell, the hive was again locked and moved to another strange environment, 15 miles from the previous location. Four feeding stations were erected, one in the training direction to the northwest, the other three at equal distances to the northeast, southeast, and southwest. At 7:15 A.M., the entrance was opened and the bees allowed to fly out. The possibility of orientation by landmarks had been eliminated because the location had been changed. Four observers, one at each station, were to catch every bee as it arrived so that none could return to notify the hive.

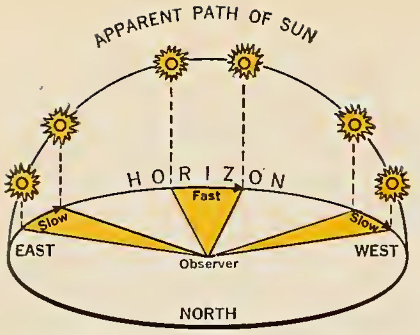
During the hours of observation, 7:15 to 11:15 A.M., the sun moves from the east to the southeast. If the bees had remembered from the previous afternoon only that the feeding station was situated between 65 degrees and 11 degrees to the right of the sun, they might be expected to appear at either the southeast or southwest feeding station.

On the other hand, a flight to the observation point to the northwest would mean that the bees did, indeed, use the sun for orientation and that they were, in addition, able to calculate its path and to compensate for its movement. Of the 30 marked foragers, a total of 19 appeared at the feeding stations during the four hours of observation. Of these, 15 had flown to the northwest. Only 4 had flown in an incorrect direction.

Thus it could be demonstrated—omitting for the moment the possibility of orientation by means of the earth's magnetic field—that bees are actually capable of using the sun as a compass. The sun's pathway across the firmament and its nightly revolution below the horizon are taken into account by the internal clock. The sun's angle is corrected as a function of time.

Their hive moved on two successive nights, bees were released each day at different time in test of ability to relate sun's position and time of day.





Steepness of sun's path determines speed of a point (the azimuth) directly below sun moving across the horizon.

This result immediately raises a new problem, one concerning astronomy. Viewed from the earth, the sun moves across the sky at an almost constant velocity. In an hour it moves just about 15 degrees. However, the celestial direction of the sun does not change with a constant velocity but with a velocity that varies with the time of day. This is illustrated above.

The direction of the sun is read from a straight line leading from the observer to a point on the horizon directly below the sun. The angle formed by this line and one from the observer to north is the azimuth angle (measured in degrees, beginning at north and progressing clockwise). It is clear that the velocity with which the point moves along the horizon depends on the steepness of the sun's path at any given moment. The steeper the path, the more slowly the point will move. In the middle latitudes the azimuth angle changes slowly in the morning and evening, when the path is steep, and more rapidly during the noon hours when the path is relatively flat.

A sun compass, then, functions with complete precision only when the changing azimuth angle of the sun is taken into account. In our case, it means that the sun azimuth orientation is really accurate only if the bees change the sun angle at varying speed during the course of the day. Like the sun, the azimuth revolves 360 degrees in 24 hours. This means that the azimuth moves at an average angular velocity of 15 degrees per hour. For approximate orientation it would therefore be sufficient for bees to assign to the sun angle a constant velocity of 15 degrees per hour.

The displacement experiment between St. James and Davis was also designed to answer the question of how bees change the orientation angle during the course of a day. The bees had been trained in Long Island to a certain direction, as well as to time. The hive was situated in the middle of an open field. The feeding station was 154 yards away, exactly to the northwest, and had been designed so that it could also be used as an automatic recording station.

In order to get to the sugar water, the bees had to enter a little aluminum box through a small entrance hole. On entering they would break a ray of light, focused on a photocell, thereby closing a relay that operated a recorder and counter. Since the bees were supposed to fly to the feeder aided by their sun compass, and not guided by landmarks, the box was hung inside a plastic pail, buried up to its rim in the ground, and covered by a masonite plate. An opening in the center of the plate permitted the bees to enter.

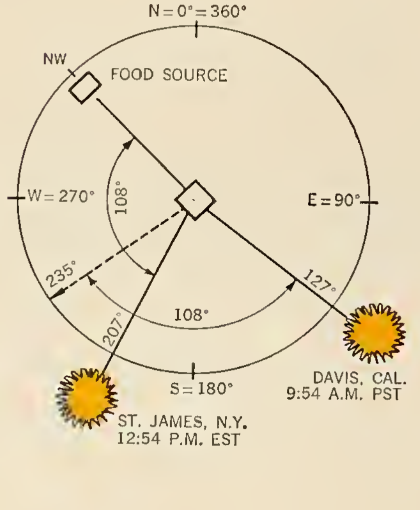
At the test area in California, registration points were set up in eight places, each 154 yards from the hive, located at northwest, north, northeast, etc., one every 45 degrees. Recording instruments and counters automatically registered the time and the place where the bees carried on their search.

A preliminary experiment at St. James, with no change in location between training and testing, had shown that bees would search not only at the correct time but also in the correct northwesterly direction. One could conclude that on every search flight they would keep to the angle of the sun that had been valid 24 hours before. Were this indeed the case, and should the bees actually use the sun azimuth for orientation, one might expect that they would not search in a northwesterly direction after displacement to the new location. For example (as shown at left, below), in St. James the bees would have had to hold to a course at an angle of 108 degrees to the sun's azimuth when flying to the northwest feeding station at 12:54 P.M., EST. Once in every 24 hours this course would lead directly to the goal. Twenty-four hours later in Davis, California, however, it would only be 9:54 A.M., PST, and the sun would be in the southeast at an azimuth of 127 degrees. Should the bees calculate their angle with respect to the sun azimuth that had been correct 24 hours before on the East Coast, they would search at an azimuth of 127 degrees +108 degrees; in other words at 235 degrees, somewhere to the southwest.

Should these search flights, as expected, extend over a period of some hours, their direction would have to change in the course of the day. The difference between the true local time at the training ground on the East Coast and the test location on the West Coast amounts to the same three hours and fifteen minutes all during the day. The difference in sun azimuth, on the other hand, varies considerably during the course of a day, when measured simultaneously on the East and on the West coasts. For example, in the morning at 10:24 EST—corresponding to 7:24 A.M., PST—the difference in azimuth between the two locations is 47 degrees; three hours later, however at 1:24 P.M., EST (10:24 A.M., PST) it amounts to 82 degrees.

This phenomenon is caused by the varying rate of movement of the azimuth angle of the sun. The difference between the sun azimuth positions, measured simultaneously at two locations separated in an east-west direction, changes as does the distance between two people—one following the other—if each alters his pace periodically. Sometimes they are close; sometimes farther apart.

One can calculate in advance



If bees oriented according to angle of sun and food source in St. James, after displacement to Davis, they would search, incorrectly, at 235°.

where the bees will search after displacement if they use any one of several available modes of orientation. For example, it is possible to plot the search directions the bees would take if they oriented according to a hypothetical sun azimuth angle that changes at a steady rate of 15 degrees per hour. Or one can plot the direction they would take if they compensated exactly for the correct, varying azimuth angle.

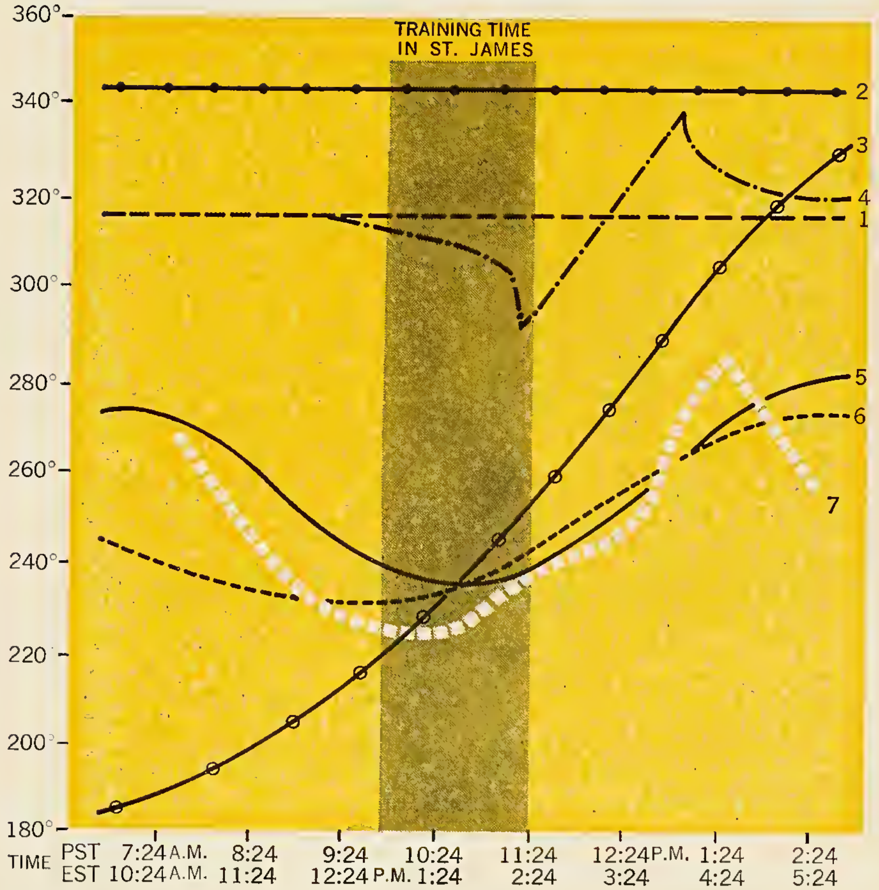
Similarly, a plot can be projected that would account for orientation by means of the earth's magnetic field. Since the magnetic declination is 11 degrees west in the eastern United States, but 17 degrees east in the West—in other words, since there is a total difference of 28 degrees—it is possible to anticipate search directions if the bees did, in fact, navigate by magnetic fields.

Another mode of orientation, one we are also able to plot, would permit the bees to manage without a time sense; they would merely have to register and associate the altitude of the sun with a specific sun angle—the angle they maintain in their approach to the feeding station. Since, apart from the moment of exact sun time noon, each height of the sun occurs twice in the course of a day, once on the way up and once on the way down, this mode of orientation can function without ambiguity only if the direction of the sun's up or down movement can be obtained quickly and constantly. Assuming this condition could be met, bees should search exactly in the training direction after a distant east–west displacement along a parallel. This would be true because the sun azimuths belonging to a specific sun height would have the same value at Davis as at St. James.

In the graph at right, the training direction and some of the theoretically expected search directions are shown as a function of the time of day. The ordinate shows direction in degrees of azimuth, where 180 degrees is south, 225 degrees southwest, 270 degrees west, and 315 degrees northwest. Curve 1 indicates the training direction (NW=315 degrees). This, then, would have been the direction of search if the bees had been in a position to find the training direction at their new location. Curve 2 shows the direction of search that would have resulted if the bees had used the lines of force of the magnetic field. Curve 3 is the expected direction of search if the average sun angle during the training period had been retained continuously during the course of the test days. Direction of search guided by a combination of the sun's altitude and angle would lead to locations along curve 4. Deviations from an angle of 315 degrees, especially around noon, are caused by the difference in latitude between the two locations; Davis lies 2.4 degrees to the south of St. James. Curve 5, finally, marks the directions that foragers would have to take if their angle of orientation had changed at a varying velocity, while curve 6 sketches the directions taken if the angle changed at a constant velocity of 15 degrees per hour.

Without, at this time, taking up any further possible mode of orientation, we shall now turn to the results. Curve 7 is drawn along the *actual* search directions taken during the three test days. The number of search impulses, averaged per hour, forms the basis for the plot. This curve indicates clearly that bees neither possess an unknown method of orientation that would permit them to determine azimuth direction correctly after large-scale displacement, nor can they utilize the earth's magnetic field. They do undoubtedly use the sun azimuth, although the altitude of the sun does not play a role. The sun's angle is corrected as a function of time. The question of whether this correction occurs with a varying or a constant velocity cannot be answered without ambiguity. The position and form of the results allow us to presume, however, that it changes with the same variable velocity as the azimuth of the sun changes in the course of the day.

The ability to take the lapse of time into consideration is of utmost importance for bees. It permits them to carry on activity at the right time, to correct the angle of their dance and of their orientation as they depend on time, and to give precise information on the location of food and its distance from the hive.



In addition to the search directions actually taken by the bees (white line), graph shows hypothetical search directions: those that would have resulted had the bees been able to navigate by using any one of several possible modes of orientation.

BOOKS IN REVIEW

The illustrator's art

By Elaine Evans Dee

FISHES, by Markus-Eliezer Bloch, edited by Eva Mannering. *The Ariel Press, $9.75; unpaged, illus.* GERARD VAN SPAENDONCK, FLOWERS DRAWN FROM NATURE, edited by Wilfrid Blunt. *The Leslie Urquhart Press, $17.50; unpaged, illus.* THE BEST OF REDOUTÉ'S ROSES, edited by Eva Mannering. *The Ariel Press, $9.95; unpaged, illus.* MR. GOULD'S TROPICAL BIRDS, edited by Eva Mannering. *The Ariel Press, $9.95; unpaged, illus. All distributed by Taplinger Publishing Co.*

Like Kipling's Elephant's Child, man has always had an insatiable curiosity about his world. From prehistoric times, he has observed—and recorded in every art form—fish, flesh, fowl, and flowers of all species. His purposes in depicting nature have been as varied as the degree of his fidelity in rendering what he has seen. In the Middle Ages, for instance, the most popular of books, the bestiary, placed the emphasis on the moral lesson illustrated, rather than on exact observation of the subject matter. Yet, the herbals and natural histories of antique scholars were scientific in approach, an attitude that was revived in the Renaissance. By the fifteenth century, an awakened scientific interest brought on the beginnings of scientific iconography. Botanical illustration in particular developed in the seventeenth century to a level of amazing beauty and accuracy, and this duality of science and art produced a wealth of visual material throughout the next one hundred years. With the systematization of classification, the enunciation of principles for defining genera and species, and the establishment of uniform use of specific names by the great eighteenth-century Swedish scientist Carl Linnaeus, the cataloguing and illustrating of nature's kingdoms took a giant step forward.

Markus-Eliezer Bloch, who lived from 1723 to 1799, was a practicing physician in Berlin. As he explained in his introduction to the extensive *Natural History of Fishes*—on which the present edition, *Fishes*, is based—the study of ichthyology had occupied his leisure hours. Discovering that he knew of species that were not included in the Linnaean classification, he embarked upon his own project, which developed, in the French edition, into a twelve-volume work of 432 plates. The introduction included an explanation of terms and a seven-part outline for each descriptive entry (the proportions of the parts, the position of the fins, the type of tail, the exact stratum of the scales, etc.). Each plate was to include the name of the fish in Latin, German, French, and English. The execution of the plates was done by a variety of artists; in fact, Bloch utilized many drawings from nature by a naturalist-priest, Charles Plumier, who had made his observations a century earlier. The engravings were colored by hand, employing a special technique to achieve the metallic effect of the scales.

The task of selecting only twelve subjects for reproduction from over four hundred in the original edition must have caused the editor of *Fishes* some anguish, but no one could regret that the almost unbelieveable rosy-orange and pearly-gray "Bossu," which also forms part of the cover design, was among them. The fascinating descriptions of the fish are slightly abbreviated translations of the original text.

Although the fame of the pupil, Pierre-Joseph Redouté (1759-1840), eclipsed that of the master, Gerard van Spaendonck (1746-1822), art historians today are awarding Van Spaendonck the honor that is his due. A native of The Netherlands, Van Spaendonck emigrated to Paris, where he eventually became official court painter and professor. Only one album of engraved work, *Fleurs dessinés d'après nature*, from which the reproductions of the present book, *Flowers Drawn from Nature*, were made, was executed during his lifetime. In addition, there is a small group of *gouache* and water-color drawings on vellum, made for the royal collections and now preserved in the National Museum of Natural History in Paris. From Van Spaendonck, Redouté learned the technique of painting flowers with water color, rather than *gouache*, because of the greater transparency and flexibility of water color in the shading and blending of colors. From Van Spaendonck, too, Redouté learned the method that the master had developed for making prints of floral subjects—stipple engraving instead of line engraving. Etching in dots instead of lines made it possible to print in several colors from a single copperplate. Of the twenty-four in Van Spaendonck's original album, the sixteen plates reproduced here seem to have been chosen for their variety of type and color, as well as for their inherent attractiveness. The format of the book is larger (about 20 by

14 inches) than the others under review (16 by 12 inches). In addition to the informative introduction, the individual entries reveal the vastness of Wilfrid Blunt's knowledge in this field, and they are written in a lucid and engaging literary style. History, poetry, significant facts, anecdotes, and suitable quotations are combined in a highly interesting manner beneath a miniature outline version of each flower to simplify the process of relating text to plate.

Patronized by the Empress Josephine and later by the Duchess du Berry, by nature industrious and devoted to his art, Pierre-Joseph Redouté is acknowledged to have been a genius as a painter, engraver, and entrepreneur of botanical art. He left behind a prodigious quantity of publications; among them *Les Roses* is, without doubt, the best-known. The garden at Malmaison, Josephine's estate, provided him with several hundred varieties of roses from which to draw, as Josephine had made a special effort to assemble a unique and truly glorious collection. The original album contained

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ANNOUNCING
A NEW FEATURE

In its next issue NATURAL HISTORY will present the first article in a new series, "Backyard Astronomer." This will be a continuing course in the methods and techniques of using the small telescope. The new feature, which will normally appear every other issue, is written by James S. Pickering. In his years as Assistant Astronomer at the American Museum-Hayden Planetarium, Mr. Pickering has taught countless amateurs how to get the most out of telescopic viewing of the night sky.

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170 plates engraved in color, including the floral wreath frontispiece that serves most handsomely for the cover and the title page of this new volume, *The Best of Redouté's Roses.* The descriptions for the reproductions are in French and are taken from the botanical descriptions made by Claude-Antoine-Thory to accompany Redouté's engravings. Again, in lieu of numbers, miniature illustrations identify the text with the plates. The admirable English introduction by Eva Mannering gives the pertinent facts about *Les Roses* and projects a vivid image of Josephine and Malmaison.

The fourth book, *Mr. Gould's Tropical Birds,* drawn from the next century, the nineteenth, is a selection from the monumental publications of John Gould (1804-1881), an English ornithologist, whose lifework produced the staggering total of forty-one folio volumes containing nearly 3,000 lithographs of birds from every part of the world including the Himalayas, Australia, South Amer-

ica, and Europe. An accomplished naturalist, Gould was also an indefatigable traveler, an energetic collector, and an acute businessman. His extensive collections of stuffed birds were purchased by the British Museum (Natural History) and the Academy of Sciences in Philadelphia. John James Audubon consulted with Gould in the course of preparing *Birds of America.* The plates for Gould's folios, based on his own sketches or taken from specimens he collected and preserved, were made by his wife; by Edward Lear, the author of the *Nonsense* books; and by other artists. Gould provided the descriptive texts, which are quoted in the present volume. Perhaps his most famous, and certainly his most ambitious, set of folios was the *Humming Birds,* some of which are included here along with other birds of spectacular and stunning plumage.

Since the reader does not have easy access to the original volumes, which usually reside in rare-book rooms, the publishers and printers of these four books have performed a service in tackling the truly difficult task of reproducing from these works and making them available. Although they could not perhaps achieve all the subtle nuances of the flowers, the warmly brilliant display of the birds, or the fluorescence of the fish, the books serve as a useful and delightful introduction at a modest price. Certainly the effort was made to be as faithful to the originals as possible in color, size, paper, and format. One wistful note from the reviewer: for those who are inspired by these books to pursue the study of the magnificent albums of engravings and lithographs from which these reproductions were taken, it would have been helpful if some reference to the plate numbers of the original prints had been made.

Elaine Evans Dee is Assistant Curator at The Pierpont Morgan Library, N.Y.C. Her special interest is master drawings.

THE ATLANTIC SHORE, by John Hay and Peter Farb. *Harper & Row, $6.00; 246 pp., illus.*

If there is a better handbook to the natural scene along the seacoast of the Northeast, I have never found it. As the subtitle, *Human and Natural History from Long Island to Labrador,* suggests, authors Hay and Farb have given us both the human background and the natural scene, from the earliest records of exploration down to the present problems of population and pollution. The remarkable fact is that they have packed so much pertinent history into a book so full of specific detail about flora and fauna. Either aspect would have made an ordinary book, but here they have been combined without any sense of skimping

The accounts they cite of wildlife along these shores when first explored by Europeans are almost incredible today. As elsewhere on this continent, the natural wealth seemed inexhaustible. Yet the exploitation has been accomplished, and much is irretrievably lost. And in their final chapter the authors bring this story of waste and spoliation up to date in what amounts to an eloquent argument for ecological understanding and intelligent conservation.

Along the way, however, they give a splendidly informed and comprehensive picture of the geology, hydrology, botany, and zoology of the long shoreline and its borders. This phase of the book makes it a must for those who would know not only what is there but where and how and why. The birds, the animals, the fish and crustaceans, the plants, and even the insects are here and properly detailed. The big picture is brought down to sharp focus on the specific in paragraph after paragraph, a high achievement even for these two able naturalists. And, for all the detail and information, the book is wholly readable from end to end. It sets the pattern for what could be a series of studies of various areas of America. If such a series isn't planned, it should be.

The book's black-and-white illustrations by Edward and Marcia Norman are excellent and splendidly complement the text. There are occasional pages where closer editing would have helped, one of the usual hazards of any collaboration. The book is rounded out with a good list of suggested supplemental reading and a detailed list of some fifty areas worth knowing along the North Atlantic coast.

HAL BORLAND
Author and Naturalist

BIRDS AROUND THE WORLD, by Dean Amadon. *The Natural History Press, $3.95; 175 pp., illus.*

THERE is a great deal of technical literature dealing with the factors responsible for the distribution of birds. Dean Amadon, Chairman of the Ornithology Department of The American Museum, brings the results of these recent studies to a wider circle of readers in this attractive little volume. Its subtitle, *A Geographical Look at Evolution and Birds*, focuses clearly on its contents. Such a look raises all sorts of questions that have long intrigued the traveling bird student. Why are the birds of the otherwise so similar tropical rain forests of Malaya, Africa, and South America so different? What determines the limits of species ranges in continuous areas, such as continents? Where does the regional zoogeographer place islands like Madagascar and New Zealand? What is the relative importance of vegetation and climate? Why are some birds common and others rare?

Against the background of such questions, Amadon guides the reader through our accumulated knowledge of ornithogeography. The understanding of the causal factors responsible for patterns of distribution has been growing rather slowly. However, it is now generally accepted that a biogeographic phenomenon is always the simultaneous product of ecological (environmental) and evolutionary (historical) factors. The respective roles of niche requirements, the significance of barriers, the effect of predators and parasites, all these and many other factors are engagingly discussed by Amadon. Having traveled in many continents and having studied the bird life of all of them, the author has a rich store of examples with which to illustrate his analysis.

The chapter headings nicely indicate the topics dealt with: "First Principles"; "The Effect of Physical Barriers"; "Ecological Requirements"; "Harmful and Beneficial Factors"; "Species Dynamics and Distribution"; "Distribution of Higher Systematic Categories"; "Geographical Patterns of Distribution—Faunas"; and "Ecological Systems of Classifying Distribution."

Admitting the importance of vegetation as an important causal factor in distribution, Amadon is nevertheless not happy with the biome theory, which he subjects to a critical analysis. Here and elsewhere the outlines of future research are indicated.

The subject matter throughout is dealt with in clear and simple language. The factual information is reliable, and I have not found any real errors, although I would have preferred to characterize Weber's Line (an imaginary line that separates distinct faunal groups) in the terms used by Amadon to define Wallace's Line—"as passing between the adjacent Lesser Sunda and Spice Islands off New Guinea and separating the Oriental and Australian regions."

The volume fulfills admirably its purpose of introducing the reader to the subject of bird geography. Every reader will be stimulated to think about the problems of bird distribution. Those who will want to follow up some of the questions in the more technical literature will be grateful for the bibliography the author has supplied. Amadon's volume fills a gap in the bird literature pleasantly and very competently.

Ernst Mayr
Museum of Comparative Zoology, Harvard

The New Museum, by Michael Brawne. *Frederick A. Praeger, $20.00; 208 pp., illus.*

The subtitle of this elegant book, *Architecture and Display*, reveals at once where the author's heart lies. The question Mr. Brawne poses is: "Should the museum be a work of art in its own right or a neutral entity?" He then shows that he doesn't really care so long as the photographs of his selected museums are both dazzling and beautiful. The result is a coffee table production of what's new in chic museums—which means, of course, mostly art museums.

There is very little "nuts-and-bolts" information in the book, and it would have been better, perhaps, to have attempted none at all. (The two pages devoted to exhibit labeling, for example, are ludicrous.) However, this does not mean that the book is without some practical value. It is useful and inspirational for designers to have an illustrated compendium of new museum concepts to study. The reproduction, especially of the plans, is better than that of the only other similar work, *Musei*, by Roberto Aloi (Hoepli, Milan, 1962). It is also a delightful, expensive souvenir for well-traveled contemporary museum buffs. Truly international in selection, the text is in English and German, and the typography is in the highest fashion of hard-to-read German sans-serif.

Gordon Reekie
The American Museum

RESOURCES AND LEGISLATION

Washington newsletter

By Paul Mason Tilden

In recent months, the press has given considerable attention to the march of events regarding the middle reaches of the Colorado River, where the Bureau of Reclamation proposes to construct two huge dams at Bridge and Marble canyons as part of its vast projected Southwest Water Plan (NATURAL HISTORY, June-July, 1964). These events have not been encouraging to conservationists who have strongly opposed further dam building in the scenic and scientifically outstanding canyon country of the lower Colorado.

There have been certain conservation successes over the past several years. One such success—of a time-purchasing nature—was the Congressional moratorium, nearly three years ago, on further dam construction on the Colorado between Lake Mead and the Glen Canyon Dam, pending a thorough review of the entire matter. However, time is running out on that moratorium, and legislation concerning both Bridge and Marble Canyon dams is afoot in the second session of the 89th Congress.

In recent weeks the appropriate subcommittee of the House Committee on Interior and Insular Affairs held public hearings and then, despite the opposition of conservationists, reported favorably to its parent committee on the Lower Colorado River Plan, the facet of the total Southwest Water Plan that includes Bridge and Marble Canyon dams. The full committee considered the report of its subcommittee, and as of this writing the legislation has been sent to the House with a recommendation that it be passed. However, opposition from all sides is strong and growing.

Conservationists, organized and unorganized, have not been alone in opposing two high dams that would considerably alter the nature of the most spectacular portion of the Colorado's unflooded remainder. A number of conservation-minded congressmen, led by Representative Saylor of Pennsylvania, have introduced bills in the second session that would in effect block construction of both Bridge and Marble Canyon dams by greatly enlarging Grand Canyon National Park in northern Arizona. The proposed park would include the existing park and the adjacent national monument, plus parts of the Lake Mead National Recreation Area, Hualpai Indian Reservation, Grand Canyon National Game Preserve, Navaho Indian Reservation, Kaibab National Forest and Kaibab Game Reserve. Included lands belonging to the Indian tribe would be administered as parkland with consent of the respective tribes. The teeth of the proposed legislation lie in a section that would cancel all existing land withdrawals for power and reclamation purposes of the Federal Power Commission and the Bureau of Reclamation (excluding those related to the Hoover and Glen Canyon dams) in the greatly enlarged Grand Canyon Park. As of this writing no hearings have been scheduled for either the Saylor proposal or for any of its six companion bills.

Over the past several years conservationists have formulated and advanced several alternative plans that would furnish as much hydropower as would be generated at Bridge and Marble canyons, but at less cost to the American taxpayer and without destruction of further long stretches of the world's greatest geologic chronometer. Two such plans would substitute coal-fired or atomic generating plants for the dams; these appear to have received less official consideration than their economic justifications would seem to warrant. Indeed the front presented by dam proponents has been impervious enough to generate the feeling among some conservationists that Bridge and Marble Canyon dams are needed as much for political reasons as for their power potential, which is very large.

The Bureau of Reclamation of Secretary Udall's Interior Department—which serves as both planning and construction agency in reclamation matters—has not been bashful in its promotion of the two dams. In its statements concerning the conservationist case for protection of the canyon's remaining lower reaches, conservationists are commonly referred to as "some people" or "those people" who fail to recognize the fact that "Reclamation *is* Conservation," and who are "sincere but misguided." (It is worth noting here that some people are not convinced that the construction of hydropower projects qualifies as land reclamation.)

Occasionally the Reclamation Bureau promotions contain material that

MR. TILDEN, a writer and editor in the nation's capital, often contributes columns pertaining to government activities and the natural sciences.

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grimly humorous to scientifically in-clined readers. For example: "I don' need to tell anyone here [in Los Ange-les] that neither Los Angeles nor any other metropolitan area of the Pacific Southwest would be in existence today a their present size and scale if man had not taken some positive steps to correc nature's imbalance of natural re-sources."

If the initial legislation in the South-west Water Plan passes the House, it wil go to the Senate, which has not as ye scheduled public hearings on the subjec and where the climate is considered les favorable to construction of the Bridg and Marble Canyon dams.

Congress and the Hudson

The "Washington Newsletter" ap-pearing in Natural History, June July, 1966, briefly summarized the wa in which a New York public utility, th Federal Power Commission, the Unite States Court of Appeals for New York the Supreme Court, and conservationist became entangled in a conservatio drama centering on the utility company application to the FPC for license construct a huge pumped-storage hydr electric plant at Storm King Mounta in the Highlands of the Hudson Rive

There have been two further develop-ments in the drama since that summar was written. The Supreme Court d clined to review the ruling of the Cou of Appeals, in effect throwing the matt back into the Federal Power Commi sion; and the FPC has scheduled ne hearings for November of this year c the utility company's license applicatio

At the time the previous "Newslette was written, I thought it best to omit t national legislative proposals that ha sprung from the Hudson River case f brief discussion in this report.

However, since the first session of t 89th Congress convened in early Janua of 1965, nearly a hundred bills have be introduced in House and Senate—most them in the House—for the general pu pose of protecting the natural, scen historic, recreational, or fish and wildli values of a relatively unspoiled segme of the Hudson River. If one uses the tot number of bills introduced as a criteric the best way of protecting the low Hudson would be to establish a Huds Highlands National Scenic Riverw Such a riverway, under jurisdiction the Department of the Interior, might clude perhaps 90 miles of the Huds commencing at the New Jersey–N York State line at the south and runni northward to the northern boundaries Greene and Columbia counties (to pa phrase the provisions of one such bil There might be a mile of riverway each side of the Hudson, with irregula ties of boundary where necessary to p tect outstanding scenery or importa

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Delores Maximena graduated from "Goldilocks" and "Little Red Riding Hood" at a very early age. Ever since she learned to read at a Detroit grade school—all through high school and the University of Michigan, books have been a big part of her life. Now her livelihood is books. In fact, she is currently working for an advanced degree in Library Science at Michigan.

All this background paid off . . . both for Miss Maximena and for General Motors. As Reference Librarian at the Research Laboratories Library at the General Motors Technical Center, she's the daily target for such questions as: What is Poisson's ratio of tetrafluorethylene? What is the daily gasoline consumption in Los Angeles County? What is the thermal conductivity of a certain steel alloy? Miss Maximena is expected to and *invariably does* come up with right answers. Her long experience, perception and skill enable her to put her finger on difficult answers quickly and accurately.

She's the kind of person that's handy to have around . . . in fact, the kind of person General Motors couldn't do without.

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natural or historic sites. Commercial and industrial uses of the river would not be barred, but they would be carried on in a manner consistent with the protective purposes of the riverway.

Another type of bill would direct the Secretary of the Interior to conduct a study of the lower Hudson, in co-operation with other government and state agencies and commissions, and report to the Congress as to how that portion of the river might best be restored and preserved for the public benefit. This category of bill usually contains a section specifically forbidding the Federal Power Commission from issuing any license for hydropower projects on the Hudson within the area of interest; some bills also make a similar provision against federal-aid road construction.

A third type of bill would establish a Hudson River Conservation Commission, composed of members of Congress and appointees of the governors of New York and New Jersey "to study and investigate the problems of the proper utilization and conservation of the Hudson River . . ." and to report to Congress on recommendations for legislation.

As this was written in late July, the House Committee on Interior and Insular Affairs, to which many of the bills in the House have been referred, was holding public hearings on one of the important bills of the second category—H.R. 13508, by Representative Ottinger of New York, who has been one of the leading House proponents of restoration and protection of the lower Hudson, which still retains a very considerable measure of esthetic charm, recreational potential, and scientific value.

With the National Parks

DURING the early part of the past summer the National Park Service held two public hearings in the vicinity of Great Smoky Mountains National Park, which straddles the backbone of the high Great Smokies in Tennessee and North Carolina. Purpose of the hearings: to present the Service's preliminary plan for establishing wilderness areas in the park under terms of the Wilderness Act of 1964 and to hear public comment on the plan.

This was the first national park to be reviewed for Wilderness Act purposes by the Service, and conservationists were particularly anxious that Service plans should reflect the fact that the great primeval parks and monuments have always been considered *de facto* wildernesses. Some conservationists had, indeed, argued before passage of the Wilderness Act that the national park system ought to be excluded from provisions of the Act for this very reason; they foresaw such reviews of the great parks and monuments as open invitations to developmental assaults.

[N]ancy and John Seletti aren't trying to save the world [Ju]st a little piece of it.

About a mile outside the Ko[rean] village of Ku Am there are a dozen young, still-tender mul[berr]y trees growing on a small hill. [Som]eday these trees and their suc[culen]t leaves will be the heart of a village industry—a silk raising [...]. That day is still many months [away b]ut it doesn't stop the village [...] from making daily inspection [...] up the steep hill, just in case. [Just] in case something miraculous [has h]appened since yesterday. After [all, i]t wouldn't be the first miracle [to ha]ppen in Ku Am. Everyone in [the v]illage knows the story of Chang [Sook], the daughter of the widow.

[T]en years ago Chang Sook's [chan]ces of survival were as slim as [...]was. Her father had disappeared [duri]ng the family's flight from [Nort]h Korea. Her mother, a seam[stres]s, worked a backbreaking day [and] most of the evening to earn [...] month. Barely enough to keep [them] from starving.

[B]ut today that's all changed be[cause] an American couple named [Selet]ti are sharing a little of their [good] fortune with a girl to whom a [little] means everything. Nancy, [John] and five-year-old Alexandra [Selet]ti are New Yorkers. They're not [fabul]ously wealthy as the villagers [of Ku] Am believe. But, they're not [poor] either. *Comfortable* probably [descr]ibes them best. They have [every]thing they really need, but [give] them ten minutes and they'll [come] up with ten things they want [that $]15 a month would buy. Luck[ily, th]ey thought of Chang Sook first.

[T]hrough Save the Children [Fede]ration, the Seletti's $15 a [mont]h is doing a remarkable num[ber o]f things. First, Chang Sook's [imme]diate needs and future school[ing ar]e being taken care of. The fam[ily is] getting help, too: Enough to [enabl]e Chang Sook's mother to start [a sma]ll knit shop.

[A]nd with all this, there is still [some] money left over. This money, [toget]her with money from other [spons]ors, was borrowed by the vil[lage t]o start its precious mulberry [grove]. Someday silk raising will [bring] a permanent increase in the [villag]e's income—and permanently

end the need for charity. That's what Save the Children Federation is all about. Although contributions are tax-deductible, it is not a charity. The aim is not merely to buy one child a warm coat, a new pair of shoes and a six month supply of vitamin pills. Instead, your contribution is used to give the child, the family and the village a little boost that may be all they need to start helping themselves.

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Chang Sook writes to the Selettis. She also sends small homemade gifts to Alexandra. And she tells them of her dreams of becoming a nurse. She'll probably make it. If she does, the Seletti's investment in one girl will be repaid a thousand-fold.

The Selettis know they can't save the whole world for $15 a month. Just a small corner of it. But, maybe that is the way to save the world. If there are enough people like the Selettis. How about you?

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Few conservationists departed th Great Smokies Park hearings wit happy hearts. The Park Service's pre liminary plans for legal wilderness i that preservation included six discon tinuous tracts ranging in size from 5.50 acres to 116,000 acres, a total of 247,00 acres or less than half the acreage of th 513,000-acre park. The balance of th park would be "allocated for existin and future visitor use facilities and serv ices, a public circulation system consis ing of roads and trails, controlled mar agement roads, agricultural leases [fo preservation of the existing pastora scene] and essential staff facilities." A so included in the non-wilderness area were "lands needed to form a natural se ting for developments and from whic visitors may reach the threshold of th back country. . . ." In terms of percen ages, it seemed to many conservationis that the threshold would be considerab larger than the back country.

Another aggravation at the hearing was the "public circulation system" pr jected for non-wilderness sections of tl park. Conservationists knew that this r ferred, at least in part, to the propose transmountain road across the hig country of the park, from Townsen Tennessee, to Bryson City, North Car lina, to which they have taken strong e ception. The road represents a Pa Service compromise with proponents another park road, equally objectionab to conservationists, which has been pr jected for the north shore of Fontana re ervoir, abutting a particularly fine a heavily forested section of the park the south. The so-called Fontana-Brys City road has had a long history of co troversy, and its essentials might be interest at this point.

In 1943, the Park Service, the Tenn see Valley Authority, North Caroli and Swain County in that state signed agreement whereby the Park Service u dertook to build a road along the no shore of TVA's Fontana reservoir, l tween Fontana Village and Bryson Ci to replace a road that was to be in dated by reservoir waters. In exchan the Park Service was to receive, and receive, some 44,000 acres of outsta ing north-shore timberland for addit to the park. Save for a short stretch wi in the park on the Bryson City end, t road has never been built, since a n highway, constructed some years a along the south shore of the reserv serves as an alternate route.

Several years ago, however, the P Service was called on to make good commitment and complete the Font road. In defense of the park, conser tionists argued that subsequent constr tion of the south-shore road had alte conditions of the original contract; t the road's location in precipitous mo tain country would destroy natural

ɜnic values by requiring vertical cuts d fills of some 500 feet in places; and ɪt the road would be unduly expensive th to build and to maintain, as evinced by the short stretch already mpleted, which has been subject to ding and severe erosion of cuts and s. The Park Service has indicated that must fulfill its old contract, however, d it recently proposed the transpark ghway as a compromise solution. Con-·vationists could see little point in placing one bad agreement with an-ıer; at the Smokies wilderness hear-gs they held a firm front against both ɜ original and the compromise road.

It is understood that the Park Service ·rently has under review 22 other ma-· units of the park system, and that blic hearings will be held on at least ·en of these before the end of 1966. aring dates have been scheduled for) of the units—Craters of the Moon tional Monument in Idaho (Septem-· 19) and Lassen Volcanic National rk in northern California (September ı. On the basis of the Great Smokies rk hearings, both conservationists and National Park Service looked for-rd to a long, hot autumn.

Wilderness Trails

OME sixty-six years ago one of con-servation's great elder statesmen ıceived the idea of a wilderness hiking il that would run from the high moun-ı country of northern New England vn the crests of the blue Appalachians 'peaks far southward." The man was ıton MacKaye, conservationist ther of another famous American, ·cy MacKaye, the poet.

t was to be thirty-seven years, how-r, before MacKaye's dream of con-ting northern New England with the aks far southward" was to come ılly true—thirty-seven years of co-op-tive effort between federal, state, and ıicipal governments, private organi-ons, and individuals. The final result a 2,000-mile-long, four-foot-wide path snaking south from the ice-lptured summit of Mount Katahdin northern Maine to Springer Moun-. in northern Georgia, where the ient, contorted folds of the Appala-ıns commence to arc westward to-d their termination in Alabama. The palachian Trail, finally completed in 7, is perhaps the longest marked foot-l in the world, and is hiked today some 200,000 outdoor Americans.

he Trail was primarily intended as nvitation to a wilderness hiking expe-ce; a leisurely escape from the ıts, sounds, and smells of civilization. course runs the length of two national ks and through the more primitive ions of eight national forests. It runs through innumerable enclaves of ate lands, whose owners have always

shown commendable generosity in hel ing to further the Trail and its prin purpose. the wilderness experience.

But of late years the Trail has seen di ficulties. The national population i crease and its expression in more ar bigger highways, expanding powerli networks, government installations, s tows, immense housing development tramways, and summer mountain hom has operated against the concept of long wilderness trail down the Appal chians. In plain truth, Benton Ma Kaye's wilderness trail has, in places, b come a trail that serves to link remaini patches of wilderness in the mounta country of the East.

Congress has, over the past sever years, shown a tendency to become inte ested in the problems of the nation's f mous "AT." and. indeed. in the mo general idea that public foot trails mig well be encouraged in scenic and u spoiled parts of public lands all over t country. In the 89th Congress a numb of bills have been introduced on the ge eral subject. Bills aimed specifically protection of the Appalachian Trail a typified by H.R. 15076 (Hathaway which would insure co-operation of p vate organizations and individuals the same purpose. It would establish t Trail, and sufficient land on both sides it, as the Appalachian Trailway. to t exclusion of "all inconsistent and n conforming uses wherever this can be complished in the public interest." T Secretary of the Interior would be structed to set up an Appalachian Tr Advisory Committee, with which would consult on trail problems; if were deemed necessary to re-establi the route of the Trail in places to kee natural and scenic, the Secretary wo be charged with the duty.

Typical of bills that would enc age establishment of a nationwide s tem of trails is S. 3171, introduced Senator Nelson for himself and ei other Senators. Under this proposed l islation, a system of "national sce trails" within national parks, forests, recreational lands under jurisdiction the Secretaries of Interior and Agri ture would be authorized, with a sim system in state parks and forests a designation by the states.

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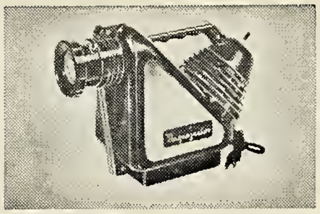

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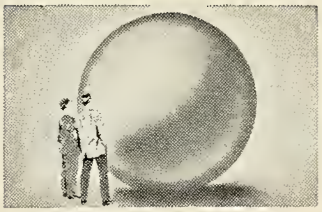

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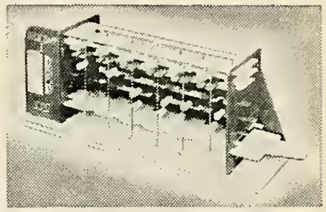

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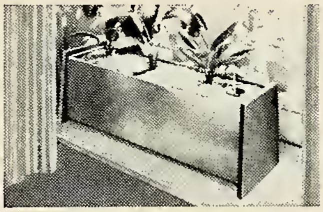

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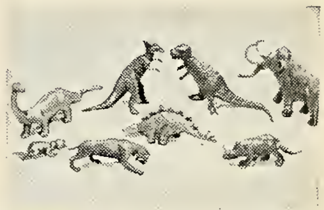

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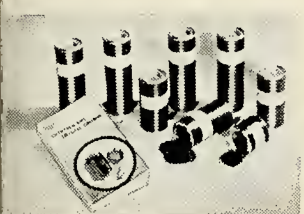

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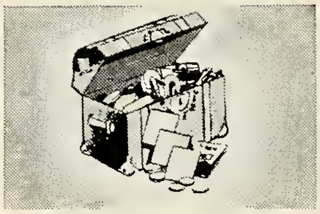

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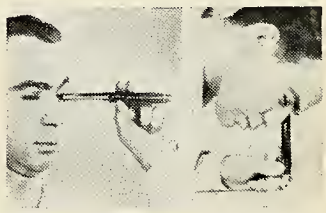

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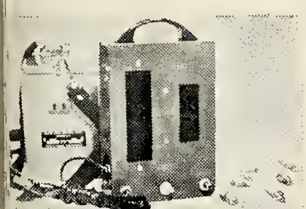

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AINU LIFE AND LORE: ECHOES OF A DEPARTING RACE. J. Batchelor. Kyobunkwan, Tokyo, 1927.

THE AINU PEOPLE OF NORTHERN JAPAN. I. L. G. Sutherland. *Journal of the Polynesian Society*, Vol. 57. No. 3, September. 1948.

THE AINU OF NORTHERN JAPAN. S. Takakura. Translated and annotated by J. A. Harrison. *Transactions of the American Philosophical Society*, New Series Vol. 50. part 4. 1960.

FLOWERING STONES

FLOWERING STONES AND MID-DAY FLOWERS. G. Schwantes. Ernest Benn Ltd., London. 1957.

LITHOPS. G. C. Nel. Hortors Ltd., Cape Town. South Africa. 1946.

A HANDBOOK OF SUCCULENT PLANTS. H. Jacobsen. Blanford Press, London, 1960.

THE TIGER AND ITS PREY

PREDATION AND VERTEBRATE POPULATIONS. P. Errington. *Quarterly Review of Biology*, Vol. 21. pages 144-177 and 221-245. 1946.

THE WOLVES OF MOUNT MCKINLEY. A. Murie. *National Park Service Fauna Series*, No. 5. Dept. of the Interior, Washington. 1944.

ZOOGEOGRAPHY: THE GEOGRAPHICAL DISTRIBUTION OF ANIMALS. P. J. Darlington. Jr. John Wiley & Sons, New York, 1957.

DESCENDING THE ANDROS REEF

ORGANISMS. COMMUNITIES AND BOTTOM FACIES, GREAT BAHAMA BANK. N. Newell. *Bulletin of The American Museum of Natural History*, Vol. 117, 1959.

ATLANTIC REEF CORALS. F. G. Walton Smith. University of Miami Press, Miami, 1948.

QUESTIONS OF THE CORAL REEFS and BIOLOGY OF THE CORALS. N. Newell. *Natural History*, March and April, 1959.

TIME AND SPACE IN THE LIFE OF THE BEE

THE ORIENTATION OF ANIMALS. G. S. Fraenkel and D. L. Gunn. Dover Publications. Inc., New York, 1961.

THE CONTRIBUTION OF THE HONEY BEE TO THE STUDY OF TIME-SENSE AND ASTRONOMICAL ORIENTATION. M. Renner. *Cold Spring Harbor Symposium*, Vol. 25, pages 361-367, 1960.

BEES: THEIR VISION. CHEMICAL SENSES, AND LANGUAGE. K. von Frisch. Cornell University Press. Ithaca, 1950.

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ARTICLES

DEPARTMENTS

COVER: Patricia Caulfield, whose article on alligators begins on page 52, suspects that the blue color of this Everglades alligator results as much from diet as from incident light. Specimens she subsequently saw in more northerly habitats were distinctly darker in color. This was the first alligator she had photographed, and she describes the experience as "somewhat testy." Her camera lens focused no closer than thirteen feet, and as long as the alligator stayed in focus, she was safe. When vision through the viewfinder blurred, as it did immediately after she took the cover photograph, retreat became imperative.

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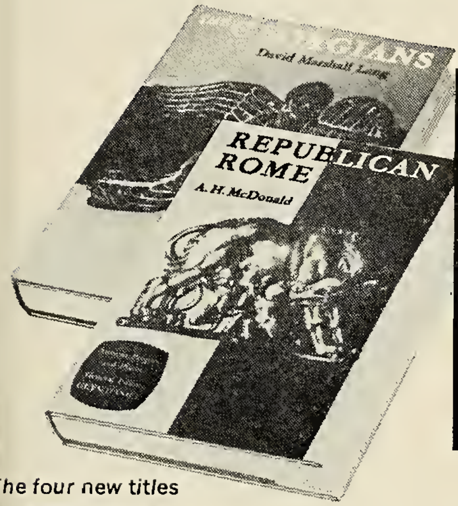

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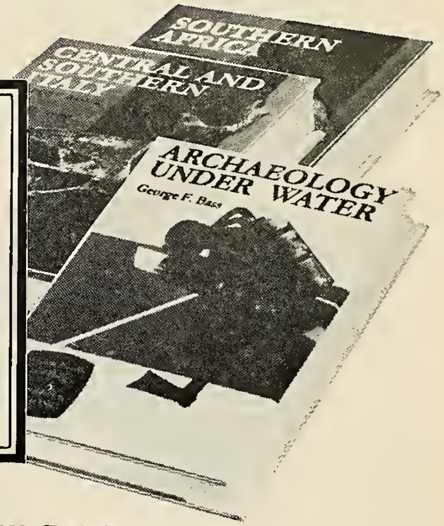

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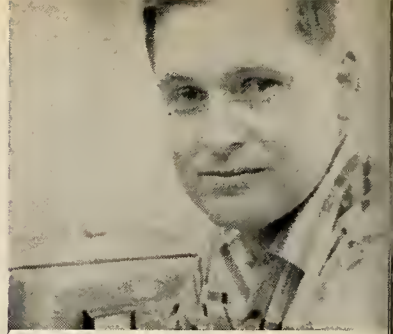

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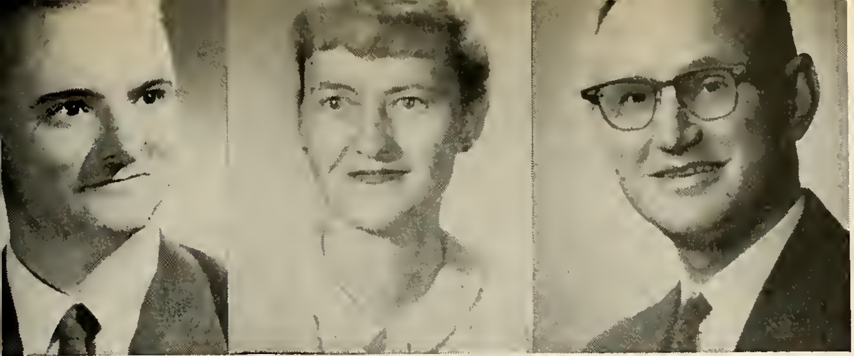

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Dr. Lee Miss Caulfield

IN LEE are Research Fellows at The erican Museum of Natural History. JOHN MCLAUGHLIN, third co-author "Some Symbionts of the Sea," is irman of the Biology Department of dham University. Dr. Freudenthal is irman of the Graduate Department Marine Science of Long Island Uni-sity, and Dr. Lee is Assistant Profes-of Biology at the City College of New k. All three have been associated 1 Haskins Laboratories. and received r doctorates in protozoology from York University. Their main en-vor is the culture of marine micro-anisms.

ATRICIA CAULFIELD, author and pho-apher of "Alligator." is Executive or of *Modern Photography*. Her in-st in the natural world and marine ogy led her to Florida where she ied the Everglades. specifically its gators, during the past year. She was d in her research and photography he Florida Game and Fresh Water 1 Commission and the National Park ice. Miss Caulfield is learning skin ng in a YWCA pool to help her in re studies. A graduate in history 1 the University of Rochester, she is ee-lance photographer and has pre-sly written for NATURAL HISTORY.

R. NANCY OESTREICH LURIE, who te the article on the American In-1, is Associate Professor of Anthro-gy at the University of Wisconsin in waukee. In 1961, she was Assistant rdinator of the American Indian Chicago Conference. She has both writ-ten and lectured on the contemporary American Indian and was, for ten years, consultant and expert witness for attor-neys representing tribal clients before the U.S. Indian Claims Commission. During the past year she was a lecturer in ethnology, under the Fulbright-Hays Program, at the University of Aarhus in Denmark. She received a doctorate in anthropology from Northwestern Uni-versity and is a Fellow of the American Anthropological Association. In addi-tion, Dr. Lurie has done field work among Indians of Wisconsin, Nebraska, and Canada.

The reviewers of NATURAL HISTORY'S 1966 Survey of Science Books for Young People are all associated with the scien-tific staff of The American Museum of Natural History. DR. RHODA METRAUX, of the Anthropology Department. is cur-rently field director of a project on the cultural structure of imagery. DR. KEN-NETH FRANKLIN is an astronomer at the Hayden Planetarium. A consultant in ecology to the Kalbfleisch Field Research Station, DR. JACK MCCORMICK is also Curator and Chairman of the Depart-ment of Ecology and Land Management at The Academy of Natural Sciences of Philadelphia. DR. ROGER BATTEN is an associate curator in the Department of Fossil Invertebrates. DR. EVELYN SHAW and KENNETH COOPER are with the De-partment of Animal Behavior—she as as-sociate curator and he as a scientific assistant.

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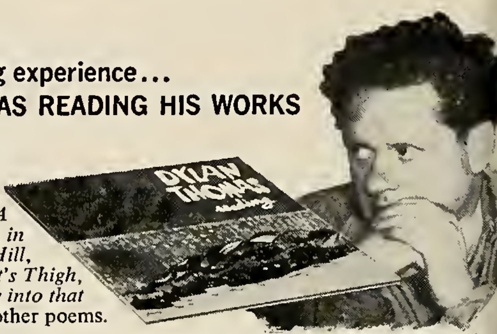

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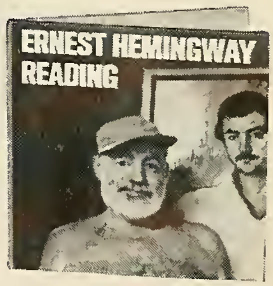

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THE ENDURING INDIAN

by Nancy Oestreich Lurie

Early next year Congress will be debating the future of the American Indian. Legislative proposals will come from the Department of the Interior, which at regional meetings this month is giving tribal spokesmen an opportunity to speak out. The following viewpoint by an anthropologist specializing in Indian studies delves into the attitudes and aspirations of the Indians today

For well over a century, the imminent disappearance of the American Indian has been predicted, albeit sometimes regretfully, by poets, missionaries, politicians, scholars, and the public at large. What are the facts? The Indian population has increased steadily since about 1900. Simultaneously, Indian cultural distinctiveness has persisted. Also, although Indians are our most "popular" minority, their standard of living has remained well below the national average.

Concerned white persons, benevolent but often woefully uninformed, are quick to offer a solution for what they imagine is the Indian problem: "Turn the Indians loose." The curious reality is that for generations we have been trying to turn the Indians loose from their identity as Indians. There has been a steady "spin-off" of individuals into the larger population for more than a century, but it has not been adequate to reverse the trend of expansion of Indian communities. If anything, it seems to select the potentially disturbing elements, from the Indian point of view, and leaves the more like-minded and determinedly Indian to perpetuate the Indian communities.

These communities distress the average non-Indian citizen as pockets of poverty and rural slums. They also distress Indian people—those who live in them and many others who live and work in cities but hope to return to their Indian communities upon retirement. Meanwhile, they visit their old homes frequently and often send children to stay with grandparents and learn tribal languages and traditions.

Such ethnic insularity is somehow un-American to many people. They become indignant when they begin to grasp what Indians seek: recognition and respect for what Indians consider their historical and legal right to be Indians, while being helped understandingly to improve their material conditions in ways that will retain, use, and develop their own cultural heritage. The opinion is often voiced that this will merely perpetuate the reservation system, which already has isolated Indians too long, permits them to live in idleness on untaxed reservation land, and accounts for their not becoming integrated. However, this argument is not convincing. There are many non-reservation communities, some of which have never had federal ties or assistance. Yet they remain as definably Indian as the official reservation communities. And in trying to adapt effectively and attain a decent standard of living they face the familiar problem. They find that sympathetic whites are too eager to help them get over being Indians entirely or else expect them to be living museum pieces.

"Indian" Culture

It is, of course, necessary to specify what we mean by Indian people and Indian culture. Including approximately 45,000 Eskimos and Aleuts, the native population of the United States and Canada is close to 1,000,000, their probable strength at the beginning of European contact. However, less than 500,000 are enrolled with the U.S. Bureau of Indian Affairs and approximately 225,000 with the Canadian departments that deal with Indian and Eskimo affairs. Both the officially recognized and the self-identified Indians are racially mixed, but usually have at least one-fourth native ancestry, most have less than one-fourth to zero non-Indian ancestry. If we were to count all the people with known Indian forebears in the way that Americans of fractional, but known, Negro ancestry are considered Negroes, we would have an "Indian population" upwards of 10,000,000. That even a tenth of that number have gone on being Indians is all the more surprising because the option to assimilate is far more open for Indians than for almost any other minority, particularly of non-European origin. In practically any chance gathering of Americans, when Indians are mentioned, one is likely to find persons proudly claiming Indian ancestry who, to all appearances, are white. This is in marked contrast to people who "pass" in the dominant population but whose success depends on keeping even remote Negro ancestry a secret.

The important point is that Indians are essentially an ethnic or cultural minority rather than a racial one; they derive their identity from association in culturally and socially distinct Indian groups. People who make up the recognized Indian population, in contrast to the many millions of whites who proudly admit to "Indian" ancestry, think of themselves first as Sioux, Navaho, Chippewa, or whatever the case may be, and secondarily simply as Indians. When we speak of Indian culture today, of course, it is not aboriginal or even the culture of the fur trade or the Indian wars so familiar to television viewers, although there are viable persistences from various past periods, as is true of any contemporary culture.

Also, we must speak both of Indian cultures and Indian culture. There are many different kinds of Indian communities, and today all have much in common with other American communities. But, to varying degrees, they also have their own interwoven complex of local features that are clearly aboriginal in origin, such as language or religion. They also have features borrowed from white culture that are now so thoroughly adapted as to be part of the local Indian culture, such as items of dress, diet, or even occupations and crafts. Then there are both aboriginal and highly adapted characteristics that have become widely diffused and are shared by many tribes. Some of this common Indian culture appears to be very old: such as decision making by consensus rather than majority rule; social control by indirection and persuasion rather than direct confrontations; and a distinctive humor and oratory, even in the use of English. Where the diffusion of traits has spread from tribe to tribe in relatively recent times, often having originated in the nineteenth-century culture of the Plains tribes and continuing to the present, the anthropological literature refers to Pan-Indian traits. These are exemplified in the costuming, music, and dance forms of modern intertribal social gatherings known as powwows. But, Pan-Indianism has also come to include a broadening awareness of "Indianness" in contrast to the white world and, particularly since World War II, the growth of intertribal organizations devoted to questions of Indian rights and aspirations. Two questions must then be raised. How hav

Indians managed to hold out this long, and how much longer can they hold out?

Now that Indians have demonstrated their staying power, we can, with hindsight, begin to discern some of the underlying reasons. At least two factors set Indians apart from all other Americans. First, theirs has been a history of distinctive customary, legal, and political relationships between each other and with non-Indians. Second, they do not have the non-Indians' tradition of immigration from another land.

A Confusion of Premises

When European contact began, tribal groups entered into compacts, treaties, and formal alliances with Europeans representing various sovereign and commercial interests. At first, Indians often held the greater power in these relationships, and for a long while—several centuries in some regions—they were able to negotiate as equals. As the competition for land began along the eastern seaboard, Indians responded by forming or expanding upon existing intertribal alliances—sometimes between once-mutually hostile tribes—a process that was to be repeated time and again as the frontier moved west. The British colonists, for their part, established a procedure that was to become the basis of Canadian and American Indian policy. When the bargaining powers of local Indians began to wane and they became a nuisance, all-out military campaigns started. The final defeat of the Powhatan Confederacy in Virginia and of the several intertribal alliances in New England during the mid-seventeenth century resulted in treaties, a familiar procedure to Indians in terms of their own negotiatory institutions and dealings with Europeans. However, these treaties demanded not only peace and loyal allegiance to the British but the relinquishment of large territories. In exchange, the surviving Indians received small parcels of land—in effect, reservations—to be theirs in perpetuity. Here, by means of new skills and utensils from the white man, they would be allowed to re-establish themselves under drastically changed ecological and political conditions.

Indians could only be dealt with then by the Crown. After the American Revolution, Indian affairs became a federal responsibility, and Congress was empowered to "regulate commerce . . . with the Indian tribes." After 1871, "agreements" were employed—much like treaties—but the substitution was an attempt to erode what the treaties had promised the Indian tribes: a status of sovereign equality with the United States. In Canada the procedures were similar, but actual treaties continued to be made into the twentieth century. At any rate, Canada and the United States, as well as the Indians, understood that no matter how

generous the payments might be for land, mere money and goods could not compensate the Indians sufficiently. So, special governmental departments were established to help the Indians adjust to their reduced circumstances, and the governments increasingly interpreted this moral obligation as helping the Indians to become indistinguishable as individuals from the rest of society.

This was not the Indians' interpretation. They looked upon treaties and agreements as permanent guarantees of a final homeland where they would have opportunity to select and incorporate new skills and utensils to re-establish effective community life in mutually agreeable relationships. Tribes had been making such adaptations voluntarily for a long time: acquiring new goods, experimenting with new economic habits in both production and consumption, negotiating with whites, and keeping their own identity as distinct communities.

It is also significant that the great majority of tribes were placed on reservations during the nineteenth century, just at the time that industrialization, urbanization, and the great influx of immigrants from all parts of Europe were contributing to the economic diversification and cultural heterogeneity of American life.

Yet our Indian Bureau clung to an eighteenth-century ideal of self-sufficient rural agrarianism, which the Indians increasingly found an unattractive and impractical fulfillment of the promise to help them become established. Sullen apathy set in on their part—and increasing authoritarianism on the part of the Indian Bureau. However, if the Bureau could not make much progress with the folks at home, it began to take pride in the record of those Indians who were exploring the opportunities of the cities.

The Tribal Tradition

RELATED to this underlying confusion of premises regarding governmental obligations is the second important factor: Indian traditions are not "our" traditions. The Indian removals and regroupings of the nineteenth century were unlike the migrations of adventurous or dissident individuals or families willing to dissociate themselves from their societies of origin for political, economic, or religious reasons. Nor were Indian removals, albeit sometimes under duress, like the transport of slaves from Africa. Negroes were brought as cargoes of individuals having little in common but their fate of captivity. Any lingering ties of community to Africa were systematically destroyed by their dispersal over a broad agricultural region.

In contrast, the Indian communities had not lost their traditions. They retrenched with either all, or a significant segment, of their usual personnel still

Continued on page 18

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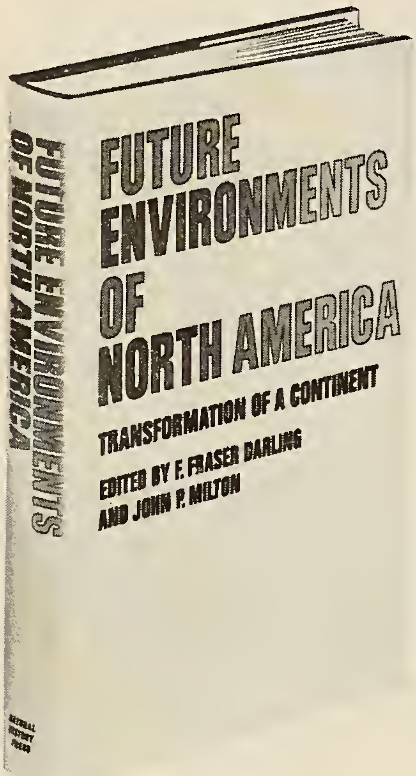

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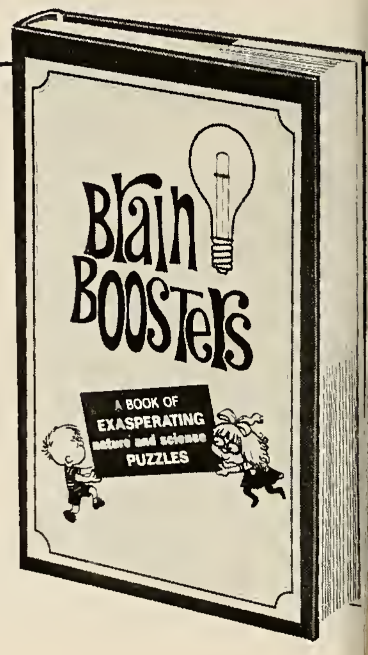

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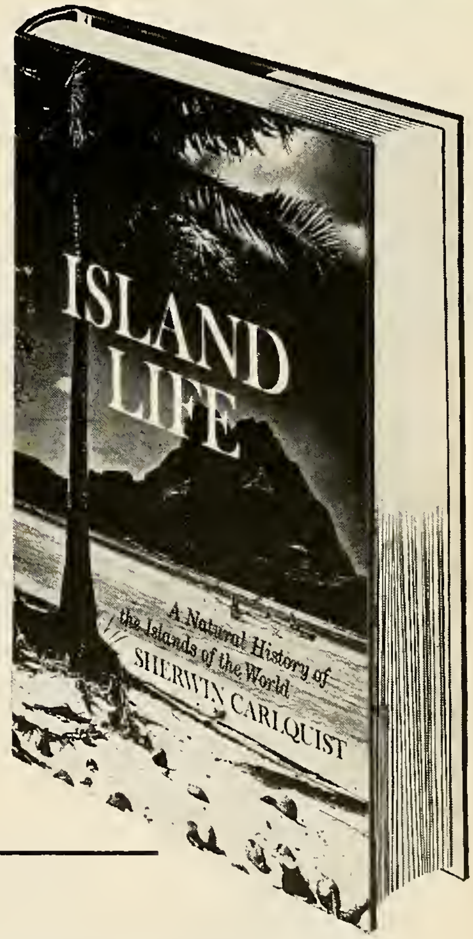

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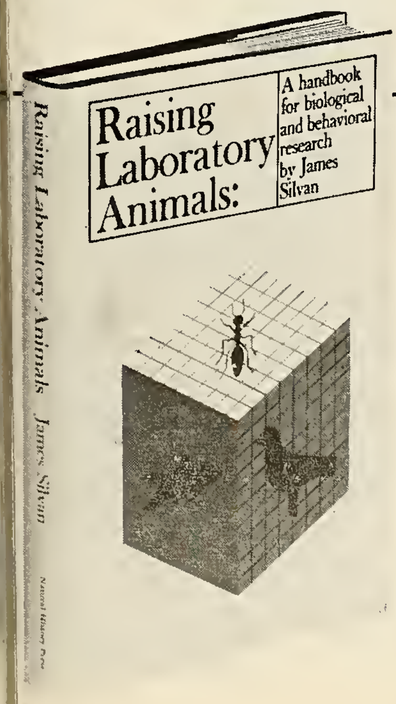

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continued from page 13

structurally interrelated by kinship and other institutions determining mutual obligations and responsibilities. It was largely only the outward, most easily controlled features of Indianness that could be dealt with or changed—such aspects of simple survival as housing, clothing, and diet.

True, today's Indian communities can hardly be considered tribes according to precise ethnological criteria of social organization and leadership. But they derive directly from a tribal, rather than a peasant, tradition. Despite long contact with whites, most were still tribally organized in the nineteenth century, when they encountered the Industrial Revolution. By contrast, Americans with a European or even Asiatic background generally share cultural traditions that evolved gradually along a peasant–urban continuum. This is also true of the long detribalized Negro in America. He went largely from rural slavery to tenant farming. We are all conditioned to look to the urban industrialized centers directly as models in patterning our lives as individuals. We feel ourselves part of a cohesive over-all tradition.

Most Indians have a different and more eclectic perspective. They tend to look to other Indians and their successful experiments for models in selecting and adapting elements of the larger tradition while resisting absorption into it. Theirs is a tradition of negotiation, accommodation, and community articulation in regard to outside social and economic opportunities. They are not alone, of course. Gypsies and certain religious sects seem to operate in the same way in the United States, but Indians expect help—or at least acceptance of their adaptations—to compensate for lands only they surrendered to the government.

Pan-Indianism

But what of the future? Opinions differ but seem to center in the old and still expanding phenomenon of Pan-Indianism and the more recent movement of Indian people to urban areas since about the time of the First World War, a period that saw the development of intertribal neighborhoods and Indian social centers. It is argued on the one hand that, to accommodate all the local tribal differences, Pan-Indianism will become so thin and synthetic that it will dilute Indians out of existence as a distinct minority or, at most, result in the kind of bland, urban, middle-class cultural pluralism that characterizes most immigrant ethnic groups after several generations. On the other hand, it is noted that Pan-Indianism seems to enrich, rather than replace, local tribal cultures and establishes a bridge for communication and transmission of innovations, in both di-

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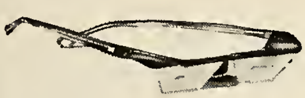

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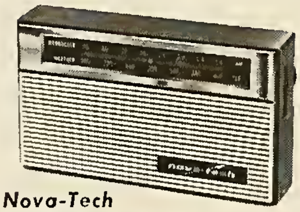

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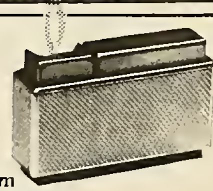

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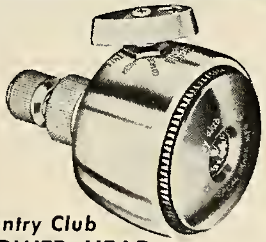

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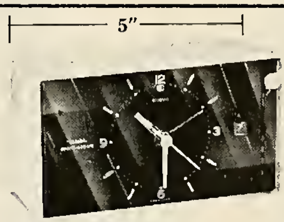

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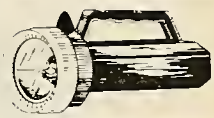

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rections, between the Indian communities and the urban neighborhoods. Other ethnic groups are cut off from their countries of origin, preserving attractive segments of their original traditions but not operating as a dynamic part of those traditions. Furthermore, for many years, the educated or skilled individual Indian able to find a place in the urban environment could only choose between relative prosperity by integration into the larger population or acceptance of the dismal poverty of Indian community life in exchange for its attractive sense of Indianness. As a result, much potential leadership in terms of the educated members of the group was regularly drained from the Indian communities. But as more Indian people began to cluster in the cities, where Pan-Indianism flourishes as the major expression of Indianness, these once marginal people became increasingly acceptable and useful to their communities. They can demonstrate a continuing and active concern for their Indian heritage in Pan-Indian terms while in the city, and can participate in Pan-Indian and even local activities when back in their communities. They are becoming the agents to select and control innovations in Indian terms and transmit them to the communities. While we now have established urban Indian neighborhoods, the local communities are becoming better able to persist if permitted to do so.

However, even if tribal distinctiveness can flourish under prosperity as it has under adversity, it is fair to ask whether Indian objectives are realistic in trying to develop essentially rural areas in an increasingly industrialized nation. Indian people believe there are now enough successful experiments in stock raising, small assembly and manufacturing plants, and especially tourist enterprises, which cater directly to the recreational needs of a highly industrial nation, to justify optimism. Their main fear is that these new programs and those only in the discussion stage will not be given enough support and protection to succeed.

The Collier Policy—and After

The objective of raising the material standards of the local communities has always been attractive to Indians, but to understand the present situation we must consider particularly the impact of the administration of John Collier, Sr., as Commissioner of the Indian Bureau, 1933-1946, and the events that followed. Collier tried to develop a policy and administrative procedures within the framework of the Indians' basic understanding of the government's obligations to them. He did this by strengthening tribal self-governments to forward educational, credit, and resource development programs aimed at reducing poverty. By 1941, however, Congress was cutting back "non-essential" budgets in the war interest; it was also beginning to question, and finally repudiated, Collier's philosophy as entirely too revolutionary a departure from proper goals of the Indian Bureau. Meanwhile, the Indian population, like that of the entire nation, began to rise sharply. The return to reservations of veterans and of families who had gone to work in war industries placed even greater pressures than before on the income resources in Indian communities—despite real strides made under Collier's administration. Yet the war had been a mass educational experience for Indian people. With all the new ideas and skills they had discovered, they were eager to explore opportunities under the Collier programs.

However, because no marked improvement, and even some outright regression, seemed to characterize the economic situation among Indians immediately after the war, Collier's ideas were blamed. Community development along the lines that Indian people found acceptable was thus scheduled to be scrapped at the very time that significant numbers of

them were becoming prepared to utilize and expand upon the Collier program.

By 1950 a drive was under way to terminate federal jurisdiction over reservations; and with it any federal responsibility for Indian welfare other than to move as many Indians to urban areas as could be convinced to come under provisions of the "Voluntary Relocation Program."

There is little question, however, that a drive for what Indians consider their long-neglected rights has been gaining momentum since the 1950's. Although clearly a continuation of the Pan-Indianism that started in the nineteenth century, perhaps even of intertribal alliances that characterized resistance to the threat of the frontier, it has taken on increasingly purposeful political characteristics. Indian people are banding together on a regional and national scale to make their goals explicit and win the understanding and support of the larger, white public. It is not a single, co-ordinated movement, and it contains factional differences. The factions reflect differences of opinion that have long split Indian groups on the community level in their search for effective adjustments to the larger society. Possibly the majority of those "grass roots" Indians who are not politically active or vocal are, nevertheless, in sympathy with spokesmen for the idea that Indian problems can be met by re-establishing firm and traditional treaty relationships between Indian tribes and the governments of the United States and Canada. Some members of this faction even argue that recourse should be to the United Nations rather than to American and Canadian departments in charge of Indian affairs.

But the majority opinion of politically active Indians is more moderate. They seek protection of Indian lands and resources as a matter of historic obligation on the part of the national governments. They seek economic development to raise the general level of Indian life, but also respect for Indian cultural and social distinctiveness as long as the Indians wish to maintain it. Let us be plain about this. Indian people of both traditional and moderate views are not opposed in principle to loss of Indian identity or assimilation into the dominant society. They only insist that this should be an individual option, to be neither forced nor discouraged, but freely and honestly exercised by means of improved educational opportunities, which should apply to the professions as well as the manual skills so long emphasized in governmental and private benevolent work among the Indians.

The moderate spokesmen are usually better educated than the majority of Indians and for this reason more prosperous. They are gradually being recognized by Indians as trustworthy and are gaining ascendancy over those leaders who, whether by education or special talents, had capitalized on their Indian heritage and early learned to manipulate the Indian Bureau, missionaries, and other whites for personal gain. Such "professional Indians" were supported and accepted by whites as tribal leaders because they were culturally more white than Indian and were considered models for other Indians. However, it was the moderate faction that assumed leadership in opposing the threat to Indian community life in the 1950's.

This policy was approved, and legislation to carry it out was passed by the votes of people who sincerely believed they were at last granting justice to the Indians. It was promoted and widely accepted on the basis of analogies to the Negro movement for civil rights, which was then gaining momentum. Indian people were thereby placed in the unhappy role of seeming to oppose decent American sentiments—desegregation, equality, freedom. At first, many Indian people believed the publicity that Congress was at last going to do something

in their behalf, that it would attempt to correct and improve shortcomings in the Collier program. But their unified opposition became apparent when they began to understand what was really involved.

Certainly they felt deprived and unjustly treated on the reservations; but they did not feel "segregated," as this term is only too sadly understood by Negro people. Now the Indians faced that prospect. Although the idea of joining Indians to the great white middle class had always underlain governmental objectives, the relocation program, coupled with plans to terminate reservations with all possible speed, nearly succeeded in putting large numbers of unskilled and meagerly educated Indian people in the same position as the majority of urban Negroes. Indians would have been deprived of their home communities and their opportunity to develop their own traditions. Many would have been ill-equipped in the competitive individualism of the dominant population to make their way to higher levels in the urban environment. These Indian people would very likely have had no escape, socially or psychologically, from the denigrating implications of segregation. The risk of becoming identified, along with Negroes, both as part of the lowest economic rank and of non-European origin, raised the strong likelihood that Indians would be subject to the kind of generalized racial prejudice they had thus far been spared. And it would include those who were making their own way adequately as well-integrated spin-offs or Pan-Indian urbanites.

It is hardly surprising, although this has alienated some "liberal" white sympathy, that Indians have shied away from involvement in the Negro movement for civil rights, and that a certain amount of deplorable but understandably defensive racism concerning Negroes is to be found among Indians. Even symbols of the Negro civil rights movement became distasteful to Indians. Marches and other forms of demonstration were dismissed as "undignified" and "not the Indian way" when sympathetic whites suggested that Indians should employ similar methods.

However, those leaders who began the movement against the policy of the 1950's, and particularly younger Indian people, are beginning to realize that the cause of civil rights has relevance for them, even though Indian goals differ in certain essential features from those of Negroes. The National Indian Youth Council, formed in 1961, actually staged their first "fish-in" during the spring of 1964 to aid Indians in the state of Washington, with Marlon Brando taking a well-publicized role as a white sympathizer. The name was inspired by Negro "sit-ins" at public eating places. The purpose of the fish-in has been to demonstrate, when game wardens appeared, that Indians claimed special rights to fish, regardless of state game laws. They had long appealed for a discussion of the matters at issue—not only their insistence on their special status but also their clear economic needs in comparison to the interests of sports fishermen. Their appeals had been ignored; hence the fish-in. It resulted, at least, in the state governor's promise to form an Indian–white study committee.

What Indians seek may not be such special or peculiar privileges after all, and even the historical, customary, and legal foundations for their contentions may have some validity. If Indians can get a broad and fair hearing, they may force a healthy reappraisal of civil rights, which popular thinking has increasingly narrowed to mean those rights denied to Negroes—or simply to vague ideas about integration. A choice of alternates can also be a right and liberty. And our American democracy is in part an aggregate of special cases and "privileges"—pacifist Quakers, strangely dressed Amish, tax-free educational and religious institutions, corporations and organizations of all kinds standing in contractual and chartered relationships to the federal and local agencies of government. Commissioner Collier even felt that respect for the distinctiveness of Indian communities would enrich the fabric of American culture by offering experiments in satisfactory community life in an increasingly impersonal, industrialized economy.

To be sure, lawyers who have argued Indian cases sadly conclude that treaties are a forlorn hope and that the Third Article of the Constitution has only come to mean that Congress can do pretty much as it pleases about Indians. Yet, not too long ago, segregation stood as law in the South, and it was a firmly accepted custom that Negroes were assigned only menial duty in the armed services. It took public awareness, debate, and understanding to begin changing the situation.

Since 1961, the Indian Bureau has been pursuing a pragmatic course. It seems to embrace the Collier philosophy in energetic efforts at community development, but is so energetic at times that it smacks of nineteenth-century authoritarianism. Simultaneously, it seems to be trying to give reassurance that it is fulfilling its "proper" job and assimilating Indians. This it does by publicizing relocation statistics and evidence of progress in almost exclusively white, middle-class terms. The Bureau is probably not to be blamed. It should know by now what Indians want, but it must answer to Congress, and Congress must answer to the taxpaying public, and the public is largely unaware of all aspects of Indian problems and goals.

Natural History's 1966 Survey

The more than 80 books reviewed in Natural History's seventh annual survey deal with the biological and earth sciences, astronomy, and anthropology and are geared to the interest level of junior and senior high school students.

Reprints of this year's survey will be made available without cost to teachers and librarians who write us on their official letterhead and include a stamped, self-addressed envelope. Any other readers who wish reprints may obtain them at the cost price of 20 cents apiece.

Requests should be sent to: Reviews, Natural History, Central Park West at 79th Street, New York, N. Y. 10024.

Anthropology

In recent years, anthropologists who have tried teaching at the high school level have been finding out what Alexander Goldenweiser already knew so well in the 1920's—that anthropology, taught seriously and well, has a tremendous appeal for younger students. The idea of culture comes to them freshly, and they enter with enthusiasm into discussions that throw light on the systematic study of man and culture.

It is interesting, therefore, that so many books intended to introduce adolescents and younger readers to the panorama of culture concentrate on the past, especially on reconstructions of the past that necessarily depend on the demanding, difficult techniques of archeology.

Much of the pleasure and interest in understanding a past that exists only in ruins and potsherds. village debris and grave furniture, or bits of stone and bone lies in knowing something about the kinds of questions archeologists can ask and the kinds of interpretation that are better than conjecture. Shirley Gorenstein's *Introduction to Archaeology* (Basic Books) combines a general discussion of the aims of modern archeology with an account of how, technically, archeologists go about their task. In six chapters on different aspects of their work, she shows how as "scholars in the university, laborers in the field, clerks and technicians in the laboratory, and creative thinkers at the end of it all, they are trying to discover the substance of ancient life and to discern the trends of cultural development." This well-documented book is valuable not only because it is clear and accurate but also because it draws on research the reader will encounter time and again in other works.

The Amateur Archaeologist's Handbook, by Maurice Robbins with Mary B. Irving (Crowell), is a serious how-to-do-it book adapted mainly to American sites. It includes a description of prehistoric American cultures, much simplified, and a discussion of actual sites and instructions on how "you" work. Fortunately, Robbins continually emphasizes the unique value of sites and the responsibility involved in excavation. The book has many excellent photographs, line drawings, and tables illustrating objects and ways of recording data. A series of appendixes lists sites open to the public, archeological societies, collections, places where training can be had, and even a summary of antiquities laws. This is not a book for the totally inexperienced amateur, but for the enthusiast who is discovering a serious purpose. Hopefully, it will lead hobbyists toward formal training.

Archeology comes into the immediate present in Gordon C. Baldwin's *Race Against Time* (Putnam) through his vivid account of how the building of modern dams, pipelines, and highways, and the expansion of modern cities, threaten man's storehouse of knowledge in the earth. Most interesting are the descriptions of the ways archeologists are meeting the challenge of this "emergency." The book gives a sense of the richness of sites still unexplored, including "historical" sites of old towns and forts long abandoned, and a clear idea of the choices that must be made in where to work. Concentrating mainly on the American experience of salvage archeology, it is an eye opener to what must be done—and done now.

Legacy of a Pharaoh, by Trevor L. Christie (Lippincott), is a brief, nontechnical, and somewhat inspirational account of one famous salvage operation, the rescue of the temples at Abu Simbel, on the upper Nile, from the encroaching waters of the new Aswan High Dam. In the first half of the book Christie describes the temples and, somewhat fancifully, their builder, Ramses II. In the second, and more interesting, part he describes the new dam and the international operation that resulted in the rescue of these and other temples and the discoveries made in new sites. Readers who enjoy this book may also find interesting Jacquetta Hawkes' *Pharaohs of Egypt* (American Heritage), a historical account that is richly, though somewhat miscellaneously, illustrated with Egyptian art treasures.

Leakey's discovery of *Zinjanthropus* has given a new point of focus to discussions of early man for general readers. *The Shattered Skull* (Atheneum) is a charming evocation for younger readers of a visit made by the author, Carol Morse Perkins, and her husband to the Leakeys' camp in Olduvai Gorge. There is no history in this "safari to man's past." What gives the book its charm is the simple, unadorned account of travel in a Land Rover from Nairobi across Kenya and Tanzania to Olduvai, which makes the present part of a picture of a very distant past.

C. B. Colby's *Cliff Dwellings* (Coward-McCann) is a book a vacationing family would do well to take with them on a visit to our national parks in the Southwest. In the brief span of 48 pages, with many illustrations, Colby provides a sketch guide to the prehistoric Pueblo ruins in New Mexico, Colorado, and Arizona that are now under the protection of the National Park Service. But for readers whose imagination has been captured by the ancient cliff dwellings, there is another book, *The Old Ones*, by Robert Silverberg (New York Graphic Society). The "old ones" are the Anasazi (a Navaho word) who lived in the Four Corners country—the Basket Makers and their descendants, the Pueblo Indians. Silverberg ties together the history of Spanish encounters with Pueblo Indians in the sixteenth century, their long prehistory as it comes up through careful examinations of their living sites, and life in still existing pueblos. He has undertaken successfully the task of writing a simple and zestful narrative account of what happened to a people over 2,000 years, building in, as he goes, just what we can know or surmise and how we know it. Archeological history, living and vivid as this, depends on a sure knowledge of the data and the enjoyment of an audience, too.

Robert C. Suggs' *The Archaeology of New York* (Crowell) is "the *prehistory* of the great city of New York as it has been reconstructed, bit by bit, through years of archaeological study." Written for younger readers, the book covers a long time span, from the drifting into the region of the first Paleo-Indians to the virtual disappearance of Indians from Manhattan Island in colonial times. Suggs uses the device of an "imaginary incident" and an evocative illustration at the opening of each chapter to give life to the rather bare descriptions of tools, graves, and living sites that are the sources of what we know. He also has the good sense to write in the first person about his own research and the differ-

# of Science Books for Young People

ences of opinion he has had with his fellow archeologists working in the same area. This is a modest book, but an engrossing one.

There is an extraordinary difference between the writing of a professional archeologist who has lived with his data and even the best-researched writing of an interested bystander. Robin McKown's *The Story of the Incas* (Putnam) is standard fare—an enthusiastic, well-read, semifictionalized history that merely draws on archeology. This is rapidly becoming an old-fashioned approach, even in its newer versions.

The Fall of the Aztecs, edited by Shirley Glubok and illustrated by Leslie Tillett (St. Martin's), is an interesting attempt to marry the almost contemporary account of the events by Bernal Díaz del Castillo to near contemporary pictures from the Aztec codices. The original idea was the artist's. It has not quite succeeded. Both text and pictures are adaptations. Bernal Díaz' account, as almost always, stands up to simplification; he cannot be downed. But the translation of the pictographs alters them so greatly that the sense of the Aztec vision is almost wholly lost in the standardizing format of illustrations for an American children's book. Somehow the artist lacked full conviction of what he himself had seen.

The reviewer who has read even a small group of the books on anthropology published in any one year cannot but hope that very soon more cultural anthropologists will draw on their field work with living peoples and write books as excellent as the best by their archeologist colleagues. We need a more balanced fare for a growing audience.

Rhoda Metraux

Astronomy

Perhaps for the first time since this survey of books for young people began, not one of the books on astronomy is a disappointment. This year, however, only four books seemed suitable for young readers.

Target Moon, by Fred Warshofsky (Four Winds), is a readable account of much of our knowledge of the moon. Beginning with ancient and primitive concepts, the book runs through the contributions of Galileo and Newton, comes up to the space probes of the Ranger Project, and sets the stage for the Apollo Project, which proposes to land men on the moon by the end of this decade. Although a few lapses betray the author's shallow knowledge of astronomy, these in no way detract from the attained goal of this book: to inform, excite, and involve the young reader in an adventure unprecedented in modern times.

With somewhat less literary success, Ben Bova has written *The Uses of Space* (Holt, Rinehart and Winston), but the book's shortcomings may be due to its origins—a series of articles in a magazine. There is considerable repetition, and more often than not, a chapter will end in such a dramatic and rhetorical climax that the following chapter may be felt to be unnecessary. Nonetheless, this book, as well as *Target Moon*, is highly recommended as a collection of opinions and predictions calculated to stimulate thinking and imagination. Such "brainstorming" may well inspire a young reader to wish to be a part of future space exploration, whether or not many of the ideas discussed by the author ever become realities.

In *The Uses of Space*, Mr. Bova discusses the prospects for exploration of the several other planets, and since his remarks should be regarded as opinions, the door is open for argument. A few of his facts are wrong (the rotation period of Mercury is not synchronized with its revolution, thus altering much of his discourse); some information has been omitted entirely, such as the rotation of Venus or the existence of the Van Allen belts around Jupiter, through which some satellites move.

To turn from the near and remote future to an event in the recent past, we consider *The First Book of Mars*, by David C. Knight (Watts). This is a well-written, factual account of the Mariner IV mission to Mars, with enough background information about the red planet to show the import of the new observations. The author has restricted himself to telling just what is required to establish man's interest in Mars, from the Babylonians to Orson Welles, and the spectacular result of that interest in the space age. His discussion of the achievements of the Mariner IV fly-by is not so complete as to be tiring, but it is enough to indicate what was new and surprising, and even tantalizing. Again, here is a book that may stimulate a certain kind of youngster to plan a career in what may be termed space engineering.

Each of these books must and does discuss the possibilities of detecting life on the moon or the planets. This exciting prospect is the theme of *Life Beyond the Earth*, by Samuel Moffat, Elie A. Schneour, and Joshua Lederberg (Four Winds). This subject, prior to about 1950, was serious only to the writer of science fiction, but was little more than idle speculation to the scientist. In the early 1950's, physics and astronomy began making sufficient advances in understanding the formation and evolution of stars—and of the solar system itself—to show that planets must be by-products of star formation. Planets, then, must be exceedingly numerous in space. At about the same time, biochemistry started on the path to knowledge of the origin of life and of the secret of heredity. The authors of this book briefly review the astrophysical developments, then with simplicity and clarity thoroughly explain the chemistry of life, its possible origins and probable history, on earth and elsewhere.

A great help to the authors' success is the artwork. The artist, Helmut K. Wimmer, has provided illustrations that are at once attractive and meaningful.

K. L. Franklin

Botany and Ecology

The eleven books reviewed this year reflect the nation's growing interest in nature. As in past years, some are excellent, some are filled with errors, some attempt to give a fresh, up-to-date coverage of a field, and others are rehashes of familiar material and seem to have little justification for being published.

Four of the books can be labeled "traveler's guides." Two of these treat major vegetation regions; the other two deal with specific geographic areas.

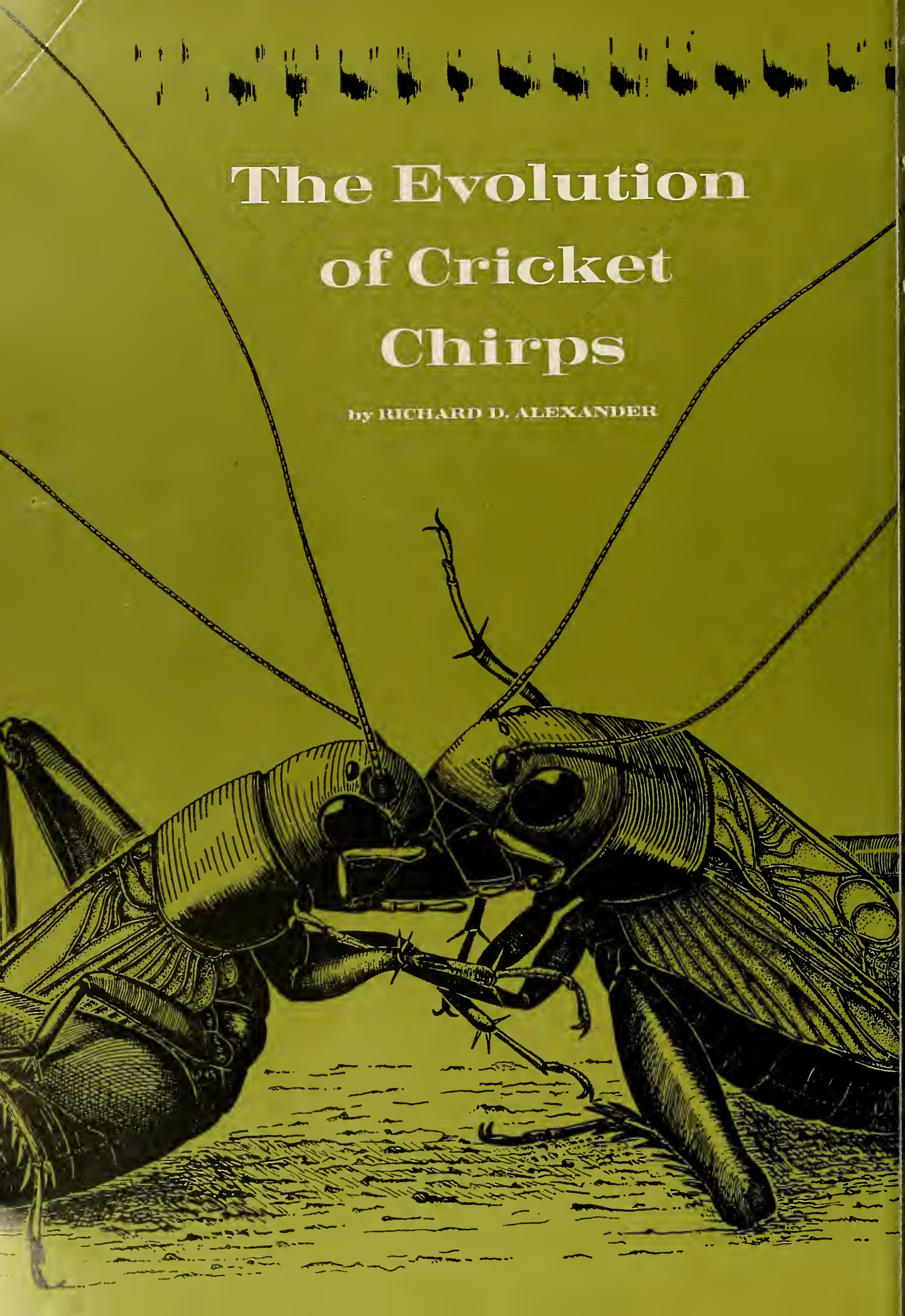
I am pleased to have in this year's review a book by Ivan Sanderson that was a pleasure to read and presents a thorough, relatively sensation-free coverage of a subject with which he is well acquainted. *Ivan Sanderson's Book of Great Jungles* (Messner) is a well-written, comprehensive description of the plants, animals, people, soils, climates, and geography of tropical forests. Although it contains a few obvious inaccuracies and numerous personifications, it is certain to be regarded as the best available popular book on its subject. Many excellent photographs complement the text and afford the reader a capsule tour of the world's tropics.

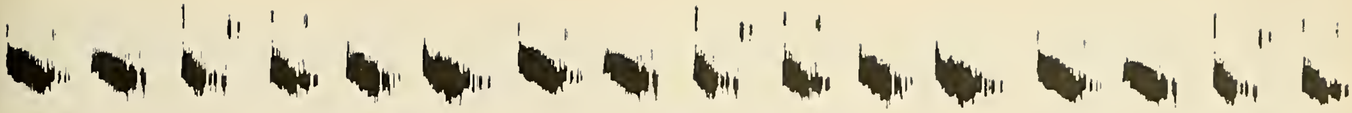
Rutherford Platt leads his readers through *The Great American Forest* (Prentice-Hall) in another outstanding book on major forest regions. He ex-

Continued on page 62

The Evolution of Cricket Chirps

by RICHARD D. ALEXANDER





O cricket, who cheats me of my regrets, the soother of slumber,
Muse of ploughed fields and self-formed imitation of the lyre,
Chirrup me something pleasant. . . .
How I wish, O cricket, that you would deliver me
from the troubles of much sleepless care,
Weaving the thread of a voice that causes love to wander away.
And I will give you for morning gifts drops of dew,
And a leek, ever fresh, cut up small for your mouth.

Modified from translation of Meleager (*ca.* 100 B.C.).
LAFCADIO HEARN. *Insects and Greek Poetry.*

Crickets must have been a particular source of curiosity for as long as there have been humans to be curious. Poets, philosophers, scientists, and primitive peoples—all have left some special indications of their interest in one kind of cricket or another. In addition to verses about crickets, written in many languages, one could cite the antiquity of cricket fighting as a sport in the Orient; the almost universal fame of Milton's "cricket on the hearth"; and the practice, developed independently in several parts of the world, of keeping crickets for food, for their songs, and for driving away "evil spirits." Even today, with so many millions of the world's population concentrated inside cities of macadam, steel, and concrete, the producer of a television show or motion picture can make his scenes nocturnal with only a token drop in light intensity if he simultaneously adds the chirp of a cricket in the background.

The source of the cricket's charm is obvious. To eliminate it we would need only to silence him, to take the acoustical dimension out of his life. But this would not be a simple exorcism. As the jigsaw puzzle of cricket life slowly assumes shape through a continuing series of investigations on behavior, classification, structure, and physiology, it is increasingly evident that a certain well-known American biologist could not have been more wrong when he wrote that, like the clanking of a knight's armor, cricket chirps were little more than the frictional creakings of an animal with an external skeleton. Indeed, those cricket groups that have lost their ability to stridulate, and along with it their hearing organs, have changed their lives and their body forms so drastically that they are excluded by some insect taxonomists from the elite body of "true" crickets.

Fossil evidence indicates that the crickets (family Gryllidae) became a separate evolutionary line some 150 to 200 million years ago, probably during the Jurassic Period, coincident with the heyday of the dinosaurs. Their acoustical system is even older than that, since their nearest relatives, the katydids and long-horned grasshoppers (family Tettigoniidae), have the same tympanal auditory organs on their front legs and the same stridulatory device on their front wings. It is possible that this is the oldest acoustical communicative system still in existence, and certainly crickets and their relatives were among the first animals to be heavily involved in transforming the previously silent terrestrial environment into the bedlam of noise it had become long before the first humans appeared on the scene.

Crickets are the master musicians of the insect world. They have, within a single species, at least as many different kinds of acoustical signals as any other kind of insect; they produce some of the loudest of all animal signals (over 100 decibels at distances of a few inches); and they are the only animals known to be capable of producing a "pure" frequency with a stridulatory, or rubbing, device. (Pure frequency means that a single frequency so dominates the sound that all others are inaudible and, for practical purposes, insignificant. Such a sound is difficult to achieve. Not even an electronic audio-oscillator, for example, has been able to produce an absolutely pure frequency.)

The cricket stridulatory and auditory organs (*page 29*) are complex devices that have evolved together as a functional unit for a long time; they could not have appeared through a single change, or even a few mutations, but had to develop through a long sequence of small, step-by-step alterations. There are no fossils of rudimentary versions of these devices, but there is evidence of their precursors among the living relatives of crickets. Non-acoustical relatives of crickets have a large clump of sensory cells, called the subgenual organ, in the same general location on the forelegs as the crickets' auditory organ. The cells apparently function as proprioceptors, supplying information to the insect's central nervous system about the position of the leg. These proprioceptive cells are believed to be the forerunners of the tibial auditory organ, and we can speculate that the device may have passed through a vibration-perceiving stage, during which it was sensitive only to transverse waves that were transmitted through the substrate. Subsequently, at one spot the cuticle thinned and special mem-

branes appeared, making the spot gradually more sensitive to the air-transmitted, longitudinal waves that we call sound.

The origin of the stridulatory device on the male cricket's forewings can also be reconstructed, in the absence of fossil evidence, through comparison of living crickets and their relatives. Most of the modern groups of winged insects that have left the oldest fossil records mate with the female climbing on the male's back. Nearly all modern crickets still mate this way, and comparative study correlating structure and behavior suggests that all their ancestors, back to the cockroach line from which they diverged during Paleozoic times, mated in the same fashion. Most cockroaches still start copulation this way (although, like some crickets, they finish the act end to end), and like the male crickets, male cockroaches raise their forewings during courtship, exposing chemical areas on their backs that attract the female into the mating position. But cockroaches never developed prominent stridulatory devices, even though some of them rustle their wings audibly during courtship, and they never developed auditory organs on their forelegs. While crickets and katydids were becoming acoustical, the cockroaches were elaborating chemical and tactual stimuli, and so they remained cockroaches.

It seems beyond question that cricket stridulation originated from the wing lifting and vibrations of courtship. If the auditory organ also evolved in this context, and it seems probable that it did, we may wonder if, during the vibration-perceiving stage postulated above, the source of vibration might not have been the shaking and wiggling body of the male as he vibrated his lifted wings. The advantage of thus providing a vibratory stimulus to the advancing and mounting female could have resulted in a stridulatory ability that would add to the vibrations (and incidentally produce acoustical effects), even before the appearance of auditory ability. This, in turn, could have set the stage for elaboration of the auditory organs and completion of the transition to acoustical living for the ancestor of crickets and katydids.

Although this hypothetical sequence involves a great deal of circumstantial evidence and speculation, the facts fit together so beautifully that, in the absence of any evidence to the contrary, the whole idea seems quite reasonable.

But to account for the appearance of the auditory and stridulatory apparatus is only the beginning of the story. These devices have been around for 150 million years, and during that time their actual structure has changed in only relatively minor ways. Crickets and katydids diverged very early and developed quite different sorts of sounds: crickets, their clear, whistle-like notes; and katydids, their lisps and clicks that are often almost of the nature of white noise (containing an extremely wide spectrum of frequencies). The auditory and stridulatory devices of the two families are correspondingly different. But there are some 2,500 known species of crickets and even more katydids. Hardly any two species have the same sounds in their repertoires. Here, in the analysis of signal diversity, are found the interesting and most difficult questions regarding evolutionary change. In many cases there are no differences at all between the auditory or stridulatory devices of species: song differences depend instead on some unknown variation in their central nervous systems or possibly in their muscles.

You may ask why species differences in cricket stridulations should always be attributed to evolutionary change. After all, humans make different sounds in, say, China and England, but a Chinese baby reared in London would speak perfect English, and a British baby reared in China would speak perfect Chinese. Not so with crickets. So far all of the environmental manipulations that entomologists have been able to dream up, short of actual mutilation, have had no effect on the kind of chirp a cricket makes, or the various chirps to which it can respond. If it does chirp, it gives the right chirp for its species, and it does so the first time it tries, after only a few raspy starts. This is really no surprise, for unlike birds and mammals, or even frogs and toads, most young crickets do not hatch from the egg until long after all individuals of the previous generation have died. This means that there can be no "culture" at all in cricket chirping. Differences among species and differences within species, in both signals and responses, have—in every case tested—been shown to be the result of genetic differences. The only exceptions are song variations such as those brought on by temperature (crickets are cold-blooded animals), and even here, the ability to respond also changes with temperature. Thus, a female cricket can recognize a singing male of her own species only if he is approximately as warm or as cold as she is.

This rigidity in the acoustical behavior of crickets typifies much of the behavior of arthropods. It is not merely a failure to evolve learning; it is another *direction* of natural selection. Selection has been minimizing the chances that the kinds of sounds a cricket makes will be influenced by sounds it hears; there are too many alien sounds in a newly adult cricket's environment, and too few chances of hearing another cricket at just the right moment. This does not make the cricket's chirp any less a product of both hereditary and environmental factors: every characteristic of an organism, after all, depends upon both factors. But the particular environmental factors involved in the development of a cricket's chirp are much more difficult to identify than some of those influencing, for example, bird songs or human vocalizations, and they are evidently less variable among the environments of different individuals of the same species.

The evolutionary elaboration of diversity in cricket signals has taken place in two contexts. On the one hand, species have begun to produce acoustical signals in new situations, and by evolving the ability to make use of such innovations, they have increased the number of effective signals in their repertoires. On the other hand, whenever speciation has occurred, the resulting species have evolved different repertoires. We have tape-recorded about 350 signals from a total of more than 200 cricket species, in 10 subfamilies and 50 genera, brought together from all parts of the world. In this entire assemblage there are only three pairs of species, one group of three species, and one group of four species that have any identical signals among them.

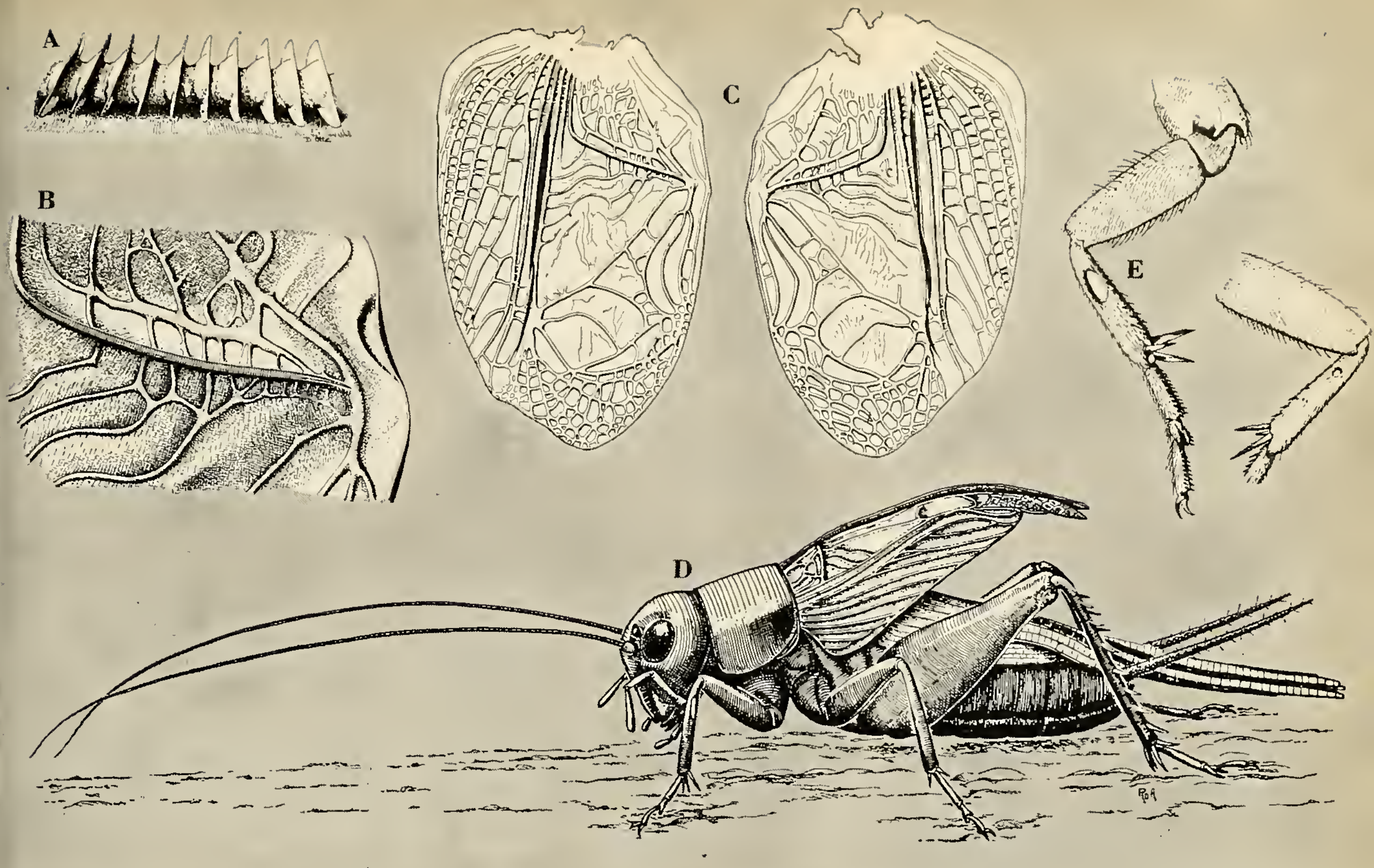


Figure resembling row of saucers set on edge, A, is enlargement of stridulatory file. Its position in wing venation is shown by B and C. In most cricket stridulation, file on right wing rubs portion of left while both wings are raised, D. Oval area on forelegs, E, is auditory organ. Section of leg at right is inner view.

What kinds of variations occur among cricket signals? First, crickets can never produce sustained tones: because they make all their sounds by oscillatory motions of the forewings, their sounds must be successions of "pulses," each produced by one stroke of the forewings. So far, all crickets recorded appear to sonify only during the closing stroke of the wings (against the slope of the teeth on the stridulatory file) and, except rarely, to open the wings silently.

A cricket can produce one pulse at a time or a few together (a "chirp" in either case, by common definition), or he can deliver a long series of pulses that may be regularly, irregularly, or not at all interrupted (a "trill"). The fastest pulse rates known are about 250 per second at 80 degrees Fahrenheit in some North American bush crickets in the subfamily Eneopterinae. Cricket sounds can also vary in frequency (cycles per second, roughly equivalent to "pitch" in human terms), and this usually relates to the size of the insect. Ordinary house and field crickets, about one-half inch long, all chirp at 4,000 to 5,000 cycles per second; some of the tiniest crickets, $\frac{1}{16}$ to $\frac{1}{8}$ inch long, chirp at more than 10,000 cycles per second; and the large mole crickets, an inch or more in length, chirp at about 1,500 cycles per second, which is about the pitch of the third G above middle C on the piano.

With one exception, all known cricket chirps are associated either directly or indirectly with the reproductive function. A student of mine, Daniel Otte, has found that one of the giant, burrowing *Brachytrupes* species, known as "bull crickets" in South Africa, makes an "alarm" or "disturbance" squawk, as do many other insects, when seized or harassed in its burrow. Aside from this exception, six functional kinds of cricket signals have been identified, and a single North American species, the short-tailed cricket, *Anurogryllus muticus*, appears to possess all of them. This is a greater variety of acoustical signals than is known for any other kind of insect, or for any fish, amphibian, or reptile, and even for many birds. Actually, relatively few mammals have been shown to have as many as six different acoustical signals, although this surely is because of inadequate study in practically all cases.

The six acoustical signals functional in the reproductive behavior of crickets may be described as follows:

1. *The calling song* attracts sexually responsive females from considerable distances—outside the range of other senses—and elicits aggressive behavior in hyperaggressive males. It is almost certainly important in the spacing of territorial, singing males.

2. *The courtship song* stimulates the female to move forward and into the mating position.

3. *The aggressive sound* causes other males to fight, chirp, or retreat, depending on the situation.

4. *The courtship interruption sound* has no proven function. It may call females back to males after accidental separation.

5. *The post-copulatory sound* may keep the mating pair together for subsequent copulation.

6. *The recognition sound* has no

proven function. Possibly it keeps groups or pairs of subsocial individuals together in burrows.

The first acoustical signal in the cricket system, produced perhaps 150 million years ago, must have been a soft sound that operated only between individuals in close proximity. Otherwise both the auditory organ and the signalling device would have had to appear suddenly, not only in complex form, but already tuned together—a possibility too remote to be worthy of serious consideration. The only soft, close-proximity signals among modern crickets are courtship sounds, and it is likely that this reproductive context was the one in which the first cricket chirp was produced. All the other signals are probably outgrowths of this fundamental situation.

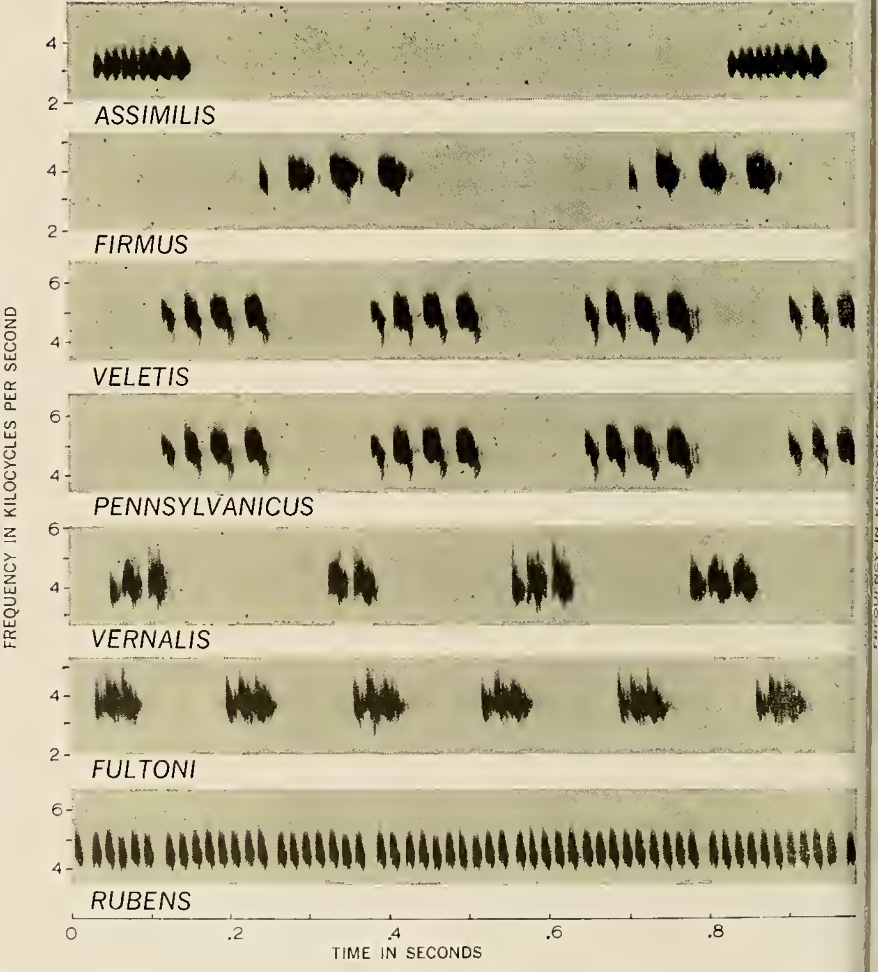
The close functional relationships between courtship and calling suggest that the calling song is principally an absentee courtship signal; it arose as a result of an original courtship signal becoming more intense and of longer duration, finally being produced in the absence of the female and attracting her without the tactual and chemical signals usually present during courtship. Special aggressive signals probably arose as modifications of the calling song after it had already become a mediator of male–male interactions, as well as of male–female interactions. There seem to be two ways in which such duality in function could have developed. One is by having the same structural sound units affect two different kinds of individuals differently (here, the male and the female). The other is by developing two separate components in the signal, one with an aggressive effect for other males, and the other a calling effect for females. The two different components can then be produced alternately during singing. Only a few crickets in Africa and Australia, among those studied, seem to have taken the second alternative, although many long-horned grasshoppers, katydids, and cicadas have done so.

Post-copulatory signals appear to have evolved from courtship singing in tree crickets. The female tree cricket stays on the male's back after the initial copulation and feeds on the secretions of a gland under the uplifted wings. Post-copulatory signals in the few field crickets that have them have evidently evolved from the calling sound. Post-copulatory sounds in these two cases are still similar to the courtship and calling sounds, respectively. Only a few crickets have post-copulatory sounds; it surprised us when we first saw a male cricket singing right after copulating, since the usual field cricket male cannot call again until he has developed another spermatophore, or sperm sac, and is ready to copulate again. That a single sound can function in these two different contexts, calling (pair forming) and post-copulatory, may result from the great difference between the two situations, which reduces the likelihood of confusion.

The so-called recognition signal of crickets is too poorly understood for much speculation about its origin, but where it occurs it seems structurally similar to courtship signals. This signal is made only by burrowing crickets that have developed elaborate parental behavior, and it is the only one supposedly produced by females as well as males.

A burrowing cricket, Valerifictorus micado, *sits in entrance hood of burrow.*

CRICKET CALLING SONGS



Audiospectrographs show calling songs of seven cricket species (genus Gryllus*).* G. rubens *"trills"; other species "chirp."* G. veletis *and* G. pennsylvanicus *have identical song but avoid confusion since they become adults in different seasons.*

This suggests that its function may be interchangeable between the sexes.

Perhaps the most significant pressure for evolutionary change in cricket songs is the advantage of distinctiveness in the calling signals of species that are reproductively active in the same places at the same times. As many as 30 or 40 cricket species may be calling together in a single habitat in North America, and if a female could not distinguish the sounds of her own males, her performance would be inefficient, to say the least. As we might expect, no two species that live together in this way have the same songs. Furthermore, some closely related species that do not live together, because they are either seasonally or geographically isolated, do have the same calling songs—in fact, almost exactly the same repertoires!

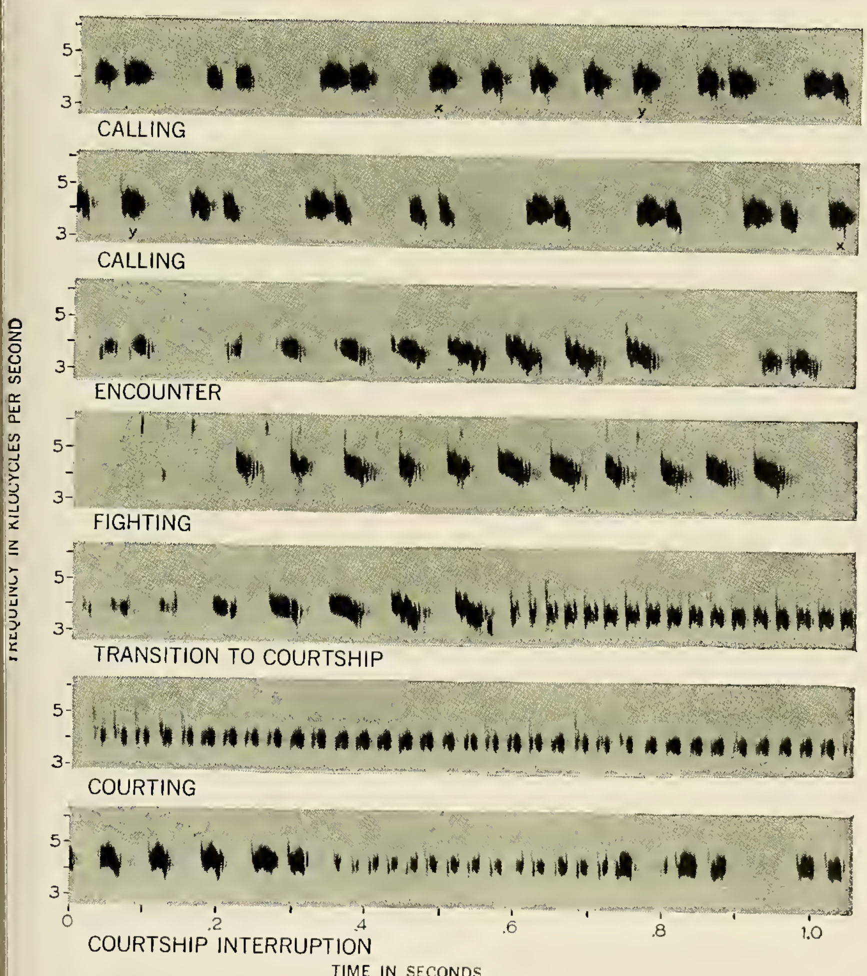
The consistent song differences between species that live together provide an extraordinarily powerful tool for the taxonomist. Using song as his single initial clue, he can obtain specimens of every species in an area within a short time. As a result, a great many puzzles in distribution patterns, morphological variation, and complexities in life histories are being solved, and some hope can be held out for accurate recognition of all cricket species in the near future, at least in the regions where field study and behavioral work can be carried out.

The most important species differences in cricket songs are in their rhythm patterns. In some cases, the stridulatory rhythms have become complex, involving pulse pairing, gradual increases and decreases in the rate of pulse delivery, and progressive, program-like changes requiring a minute or more for completion. *Teleogryllus commodus* has one of the most complex repertoires known among crickets. Its calling song is a remarkable alternation of chirps and trills, pleasant to the human ear. Among the various species from Africa, South America, Hawaii, Jamaica, and other exotic places that are continually singing in my laboratory, I particularly enjoy listening to this Australian species and reflecting that this must have been one of the loudest and most persistent sounds in the environment of the Australian aborigines all during their evolution.

European man had the fairly simple chirps of the European field cricket, *Gryllus campestris*, and the house cricket, *Acheta domesticus;* the American Indians had a whole array of chirping and trilling species. It is not difficult at night, with the light off in my laboratory—where there are often 40 or 50 species chirping and trilling together—for me to close my eyes and imagine myself alone in some primeval habitat thousands of years prior to the advent of civilization, surrounded, as men were then more than now, by the cheery bedlam of countless crickets chirping messages more than a hundred million years old.

If I sent you a message by the
crickets, through the thickets,
How'd you answer better?
American Negro Folk Rhyme

REPERTOIRE OF A CRICKET



The acoustical repertoire of the field cricket, Teleogryllus commodus, *contains two rhythms in calling song: trill (x-y) for male–male communication, chirp (y-x) for male–female. The repertoire is most complex thus far known for crickets.*

Wings raised in song, male Oecanthus quadripunctatus *perches on ragweed.*

Water and the Everglades

This fundamental element, whether profuse or scarce, rules the life and character of Florida's great park. But water, like living space, is a resource that civilization demands in ever increasing quantities. Examined here are the economics of water use by Florida's east coast cities and its effects on Everglades ecology

By William J. Schneider

The Everglades is a river. Like the Hudson or the Mississippi, it is a channel through which water drains from higher to lower ground as it moves to the sea. It extends in a broad, sweeping arc from the southern end of Lake Okeechobee in central Florida to the tidal estuaries of the Gulf Coast and Florida Bay. As much as seventy miles wide, but generally averaging forty, it is a large, shallow slough that weaves tortuously through acres of saw grass and past "islands" of trees, its waters, even in the wet season, rarely deeper than two feet. But, again like the Hudson or the Mississippi, the Everglades bears the significant imprint of civilization.

Since the close of the Pleistocene, 10,000 years ago, the Everglades has been the natural drainage course for the periodically abundant overflow of Lake Okeechobee. As the lake filled during the wet summer months or as hurricane winds blew and literally scooped the water out of the lake basin, excess water spilled over the lake's southern rim. This overflow, together with rainfall collected en route, drained slowly southward between Big Cypress Swamp and the sandy flatlands to the west and the Atlantic coastal ridge to the east, sliding finally into the brackish water of the coastal marshes.

The lower, southern edge of Lake Okeechobee lies at an elevation of about seventeen feet above sea level, while the southern end of the Everglades, one hundred miles away, disappears into Florida Bay and the Gulf of Mexico at an elevation near sea level. Such an extremely flat gradient, less than three inches per mile, causes water to flow with velocities measured in inches per day, rather than in the feet per second range that we usually associate with rivers. Because of this slow velocity and because of its extreme width (for a river) and shallow depths, the amount of water flowing through the Everglades has never been measured, except where it is somewhat artificially concentrated as it moves southward through a series of culverts in the Tamiami Trail. Indeed, a new hydrological technology is being developed specifically to cope with the Everglades' almost imperceptible rate of flow. A dye-dilution method, which will be tested in the near future, determines velocity by tracing the movement of a fluorescent dye injected into the water. Flow is registered by sensing instruments capable of detecting the dye at concentrations as low as one part of dye in ten billion parts of water.

Water has always been the key factor in the life of the Everglades. The rains that add to the spilled surplus from Okeechobee usually begin in June, and although variable from place to place, they average about 55 inches annually, with more than three-fourths of this amount falling during the wet season, June through October. In normal dry seasons in the past, water covered perhaps 10 per cent of the land surface of the Everglades. But as the rains came and as they continued through summer and early fall, and as Lake Okeechobee overflowed naturally into the Everglades, water levels would rise slowly and steadily. By late fall as much as 90 per cent of the land area of the Everglades would be inundated. Water levels would then begin their seasonal decline, remaining low through the winter. The abundant, fresh rains of late spring and early summer followed, recharging the cycle.

Throughout much of the Everglades, and prior to man's recent engineering activities, this seasonal rain cycle caused fluctuations in water levels that averaged three feet. Greater extremes, however, were also part of the natural course of events. Severe flooding resulted from hurricanes in 1926 and 1928; notable flooding occurred again in 1947. At the other extreme, and irregularly punctuating these major, and several lesser, floods, were periods of intense drought, as in 1921 when rainfall from June to September was almost 12 inches below the 35-inch normal for southern Florida. And always attending drought, of course, is the hazard of fire. Fires have occasionally been extensive. Park Biologist W. B. Robertson reported that, in 1950, 23 fires burned over 121,000 acres of the Everglades National Park. Clouds of black, acrid smoke filled the air for weeks, and along with the vegetation, thousands of tons of organic surface soils were also destroyed.

Changing water levels, floods, droughts, fires, hurricanes: all these events imposed upon the Everglades a regimen of catastrophe. Nor is the role of such demanding fare on the plants and animals well understood as yet. It may be that randomly occurring ecologic trauma is as vital

High water surrounds a cypress head in southern portion of Everglades.

Below, another ecologic extreme: a pine wood at edge of glades burns during period of drought.

to the character of the Everglades as is the over-all flat gradient. Nevertheless, despite such a seemingly catastrophic way of life, the Everglades appears almost dull to the casual observer, even if he is able to visit more than just a fraction of its total area. Except along the southern Park boundary, he sees, not a lush jungle, but vast expanses of saw grass, whose monotony is spiced only by patches of shallow open water and scattered, tree-crowded islands.

These three dominant biological communities—open water, saw grass, and woody vegetation—reflect small, but consistent, differences in the surface elevation of peat soils that cover the Everglades. Correlated to these differences in elevation, moreover, are differences in the depth of water. This is shown by the diagram at the bottom of pages 30-31. The open-water areas occur at the lower soil elevations. Inundated much of the year, they contain sparsely scattered marsh grasses, such as spike rush, and an algal mat of periphyton. The photograph on page 32 shows a close-up of rushes and the mat.

Periphyton is basically a collection of lacy filaments of algae, microscopic animals, and calcite, which forms a thick, feltlike mat on the ground and around plant stems. The mat is thickest on the bottom of the shallow, open-water pools where sunlight can penetrate the water and stimulate the growth of algae.

The saw grass communities develop on a soil base only a few inches higher than that in the surrounding open glades. The soil base is thickest under the tree islands. The few inches difference in soil depth apparently governs the species composition of these three communities, whose sizes often involve acres or sometimes even square miles.

The peat soils have developed over the centuries from the organic mass of dead vegetation. Carbon-14 dating indicates that the peat began accumulating about 5,000 years ago following the last inundation of the Everglades basin by ocean water. (Changing ocean levels had until then periodically flooded much of the Florida peninsula.) Beneath the soils is a limestone bedrock formed during the Pleistocene. The upper surface of the limestone is irregular and pitted as a result of solution by water and organic acids. The deeper solution holes occur under the tree islands, probably because organic acids formed by the roots and decaying litter of trees seep downward and etch the bedrock.

The tree islands cover 5 to 10 per cent of the 2,500,000 acres of the Everglades. This is at best a rough estimate both of the percentage of tree islands and of the size of the Everglades. The estimate on tree islands comes from a rather crude sampling of a few aerial photographs; hopefully, future studies will refine these figures.

The tree islands, like the mass concentration of saw grass, are unique to the Everglades. Depending upon species composition, they are known as either heads or hammocks: heads if willow, bay, or cypress indigenous to temperate climates are present; hammocks if tropical hardwoods such as mahogany or gumbo-limbo are present.

Bay heads obtain their name from the sweet bay (*Magnolia virginiana*) or red bay (*Persea borbonia*) that are present. Other trees, such as wax-myrtle (*Myrica cerifera*), dahoon (*Ilex cassine*), and pond-apple (*Annona glabra*), also occur in the bay heads, and coco-plum (*Chrysobalanus icaco*) usually forms the periphery. Willow heads and cypress heads also derive their names from the most populous trees in the head: willows (*Salix amphibia*) and bald cypress (*Taxodium distichum*). These, however, are often purer stands than bay heads and occur on soil elevations only slightly lower, in relation to the surrounding water levels, than the levels of bay heads.

Hammocks, as generally distinguished from bay heads, contain tropical species of vegetation. Common trees are gumbo-limbo (*Bursera simaruba*), Florida strangler fig (*Ficus aurea*), Florida poisontree (*Metopium toxiferum*), wild tamarind (*Lysiloma bahamensis*), and false-mastic (*Sideroxylon foetidissimum*). West Indies mahogany (*Swietenia mahagoni*) and the Florida royal palm (*Roystonea elata*) are rare, occurring only in places where they have managed to survive the exploitation of man. As one would suspect, the hammocks are more prevalent in the southern part of the glades. They also contain the largest variety of vegetation of any of the ecologic communities within the Everglades. In some hammocks, more than 35 tree species and more than 65 shrub species have been identified, as well as numerous vines, ferns, and epiphytes.

Today, the Everglades is no longer precisely a natural river. Much of it has been altered by an extensive program of water management. As a result, the traditional Everglades environment has been severely changed.

The Everglades from Lake Okeechobee to Cape Sable covers some 2,746 square miles. Of this, 44 per cent—1,208 square miles—has been drained for farming or set aside to be developed as farmland or residential areas. Another 49 per cent—1,345 square miles—is water conservation area under the joint control of the Central and Southern Florida Flood Control District and the U.S. Corps of Engineers. An area of 192 square miles—7 per cent of the total area—is in the Everglades National Park. The remaining small area is scattered mostly along the edges of the Everglades and is subject to future real estate development. Of the entire Everglades area, only the 7 per cent that falls within the boundaries of the Park is dedicated to the preservation of typical Everglades habitat. The rest is diked, leveed, and canalized in a massive land- and water-management complex.

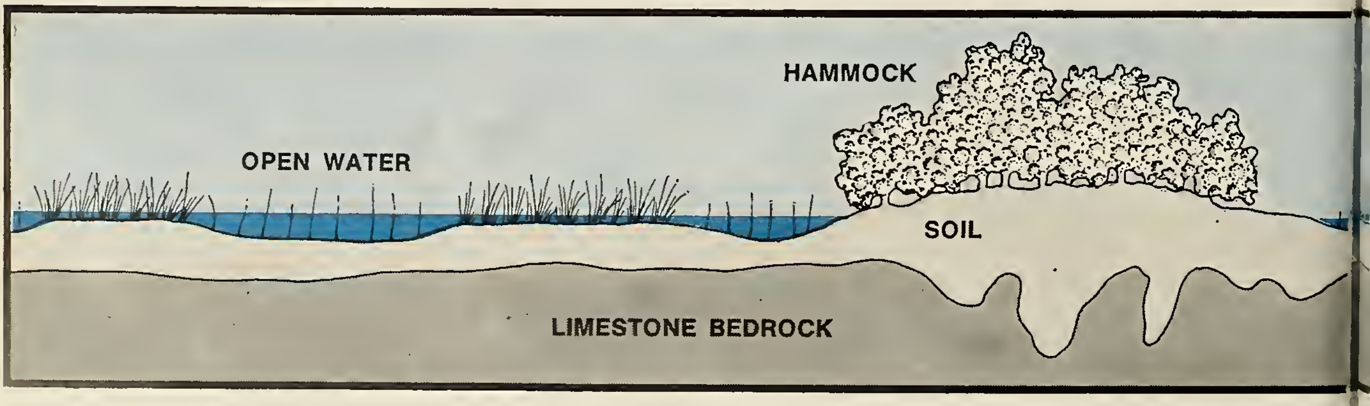
The call to drain the Everglades rang out at the turn of the century when land speculators looked to the black organic soils directly south of Okeechobee. A drainage program began in 1906 and resulted in the construction of a series of canals and an increase of Everglades landowners from a handful in 1909 to 1,500 in 1911. Commercial crops replaced saw grass as the drainage canals steadily lowered water levels. To offset the chances of reflooding, 440 miles of canals were dug and 47 miles of levees were constructed to contain Lake Okeechobee; 16 locks and dams controlled water movement. But in spite of these "flood protection" works, the hurricanes in 1926 and 1928 caused severe flooding and great losses of life and property. As a result, the Florida State Legislature created the Okeechobee Flood Control District in 1929 and

Scattered tree islands, known as heads or hammocks, provide the only relief in flat, typical

authorized it to co-operate with the federal government in eliminating flood problems caused by the overflows from the lake. By 1937, 16 million dollars were spent on gates and levees at Lake Okeechobee and on canals for flood drainage. However, during dry periods the uncoordinated canal system and the complete draining of the land resulted in extremely parched farmland. As the organic soils dried out, they oxidized and subsided, or settled. Natural compaction lowered the land surface of the drained soil by as much as eight feet, hardly an ideal situation for intensive and profitable agriculture. But that was not all. Farmers found that even with the drainage, floods still occurred. In 1948, the relative failure of all previous water control measures prompted a new plan designed to co-ordinate water management by storing the lake's overflow in giant water conservation areas south of the reclaimed agricultural land. It was thought that such a system would keep Okeechobee at a safe, non-flooding level. The Central and Southern Florida Flood Control Project was created and authorized to co-operate with the U.S. Corps of Engineers in operating the project.

In addition to protecting the agricultural lands from floods, another factor influenced the design of the new plan for water conservation. In the early years following World War II, the growth of the cities along Florida's east coast required an ever increasing amount of water for municipal and industrial use. Developed water supplies were expanded, and large withdrawals of ground water occurred. By 1965, the coastal cities from Palm Beach southward to Coral Gables were using about 300 million gallons of water each day. Of this, 196 million gallons per day (mgd) were used in Dade County, with the city of Miami supplying 138 mgd from 43 freshwater wells. For Miami, this was an increase of more than 100 mgd since 1946, when water use averaged 37 mgd. In Broward County, where water use averaged 74 mgd in 1965, the city of Fort Lauderdale itself used an average of 37 mgd.

With only small exceptions, the water supplies of these southeastern Florida cities are obtained from wells that tap the Biscayne aquifer. (An aquifer is a natural underground water reservoir.) The Biscayne aquifer is a hydrologic unit of water-bearing limestone that underlies much of southern Florida and contains its chief supply of fresh water. One of the most permeable in the world, the aquifer extends along the



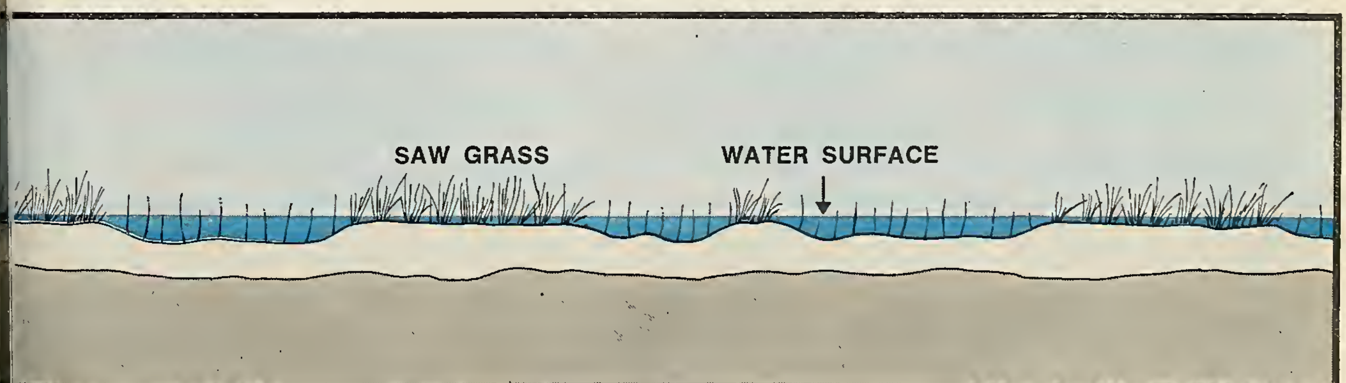
Everglades country. Below, anatomy of a hammock shows relation to saw grass and open water.

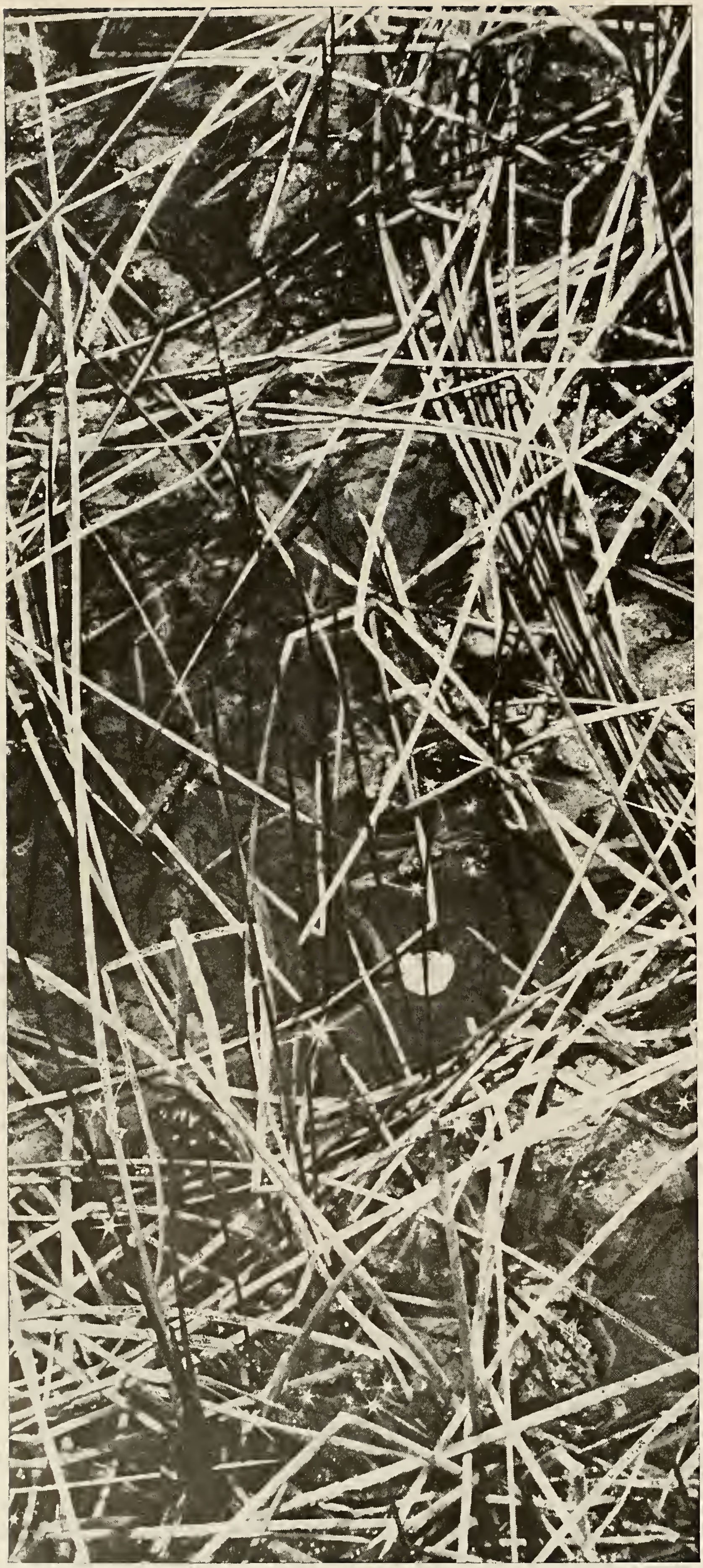
eastern coast from southern Dade County into coastal Palm Beach County. About 800 to 1,000 feet below the Biscayne aquifer is another extensive layer of limestone called the Floridan aquifer. It holds water that was trapped during the last ocean inundation (pre-Pleistocene) and that is consequently too salty for most uses. Water in some places in the Floridan aquifer exceeds 4,000 parts per million of chloride—more than 15 times the permissible standard for drinking water. Separating the two aquifers is an aquiclude, an impermeable layer of dense rock that prevents the circulation of water from one aquifer to the other.

Water pumped from the upper aquifer is normally replaced by rainfall, which enters the ground and percolates down through the soil to the rocks. But as increased amounts of water were withdrawn from the Biscayne aquifer, both by municipal consumption and by overdrainage through the uncontrolled canals that were built for land development, water levels in the aquifer were seriously lowered—an average of five feet in the coastal area—and sea water flowed inland. This contamination of fresh water took place both deep in the aquifer and in the open canals leading from the Everglades.

Prior to 1909, salty water extended up the Miami River only about one and a half miles from its mouth on the east coast, fresh-water springs flowed as much as five feet above sea level along the western shores of Biscayne Bay, and wells furnished ample fresh water, even at the bay's shoreline. Five years after completion of the Miami Canal in 1909, however, the salty water extended inland more than three miles, and fresh-water springs in the vicinity ceased to flow because of the lowered water table resulting from the drainage of the Everglades. By 1925, the zone of salt-water encroachment in the Biscayne aquifer extended inland far enough to force abandonment of the two well fields that had supplied fresh water to the city of Miami. Although only minor biotic changes occurred along the canals in the Miami area, thousands of individual wells were contaminated and many citrus trees were killed when irrigated with this saline water. The large biotic changes took place in the former fresh-water marshes south of Miami. Mangroves—indicators of salinity—extended their habitat inland, and fires raged across areas that were formerly much wetter.

The inland encroachment of salty water has been slowed or stabilized in





Where soil layer is absent, the etched surface of limestone bedrock is exposed. Above, spike rush grows where shallow soil and algae mat are present.

recent years by induced fresh-water recharge of the Biscayne aquifer and by the construction of salt-water barriers in some of the tidal canals. Induced recharge—the process of augmenting natural, rain-water recharge—is accomplished by inhibiting runoff and holding water over the aquifer for long periods. This permits more water to seep down through the soil to replenish the ground-water reservoir. Salt-water barriers—simply low dams placed near the mouths of canals—prevent salt water from moving beyond the dams to contaminate fresh-water areas. Such salt-water barriers, however, do not impede the seaward flow of floodwaters: they are equipped with gates that close only when the inland flow of salt water is likely, as during high tide.

Despite such measures, increased water use by an expanding population will undoubtedly cause further problems, both in supply and in salt-water encroachment. Population estimates by the Dade County Development Department, for example, predict an increase for Dade County (Miami area) alone from one million people in 1960 to four million people in 1995. Daily water use is also expected to rise, from 145 gallons per person in 1960 to 220 gallons per person in 1995. The per capita increase results from a projected expansion in industrial water use. The total increase will require 1.4 billion gallons of water per day, as compared with the present use of 230 million gallons per day.

To supply this 1.4 billion gallon future daily need, Kohout and Hartwell of the U.S. Geological Survey estimate that the entire amount of rainfall over a 500-square-mile area would need to be collected. They point out, however, that total rainfall is never available for use: in the Everglades, almost 80 per cent of the rainfall is consumed by evaporation and transpiration. Therefore, if the remaining 20 per cent—10½ inches per year—were diverted to the Miami well fields, it would require an area of 2,800 square miles to supply Dade County alone in 1995. This is an area as large as the entire Everglades from Lake Okeechobee to Cape Sable.

Increased water demands will probably be met by increased pumping from the Biscayne aquifer, but

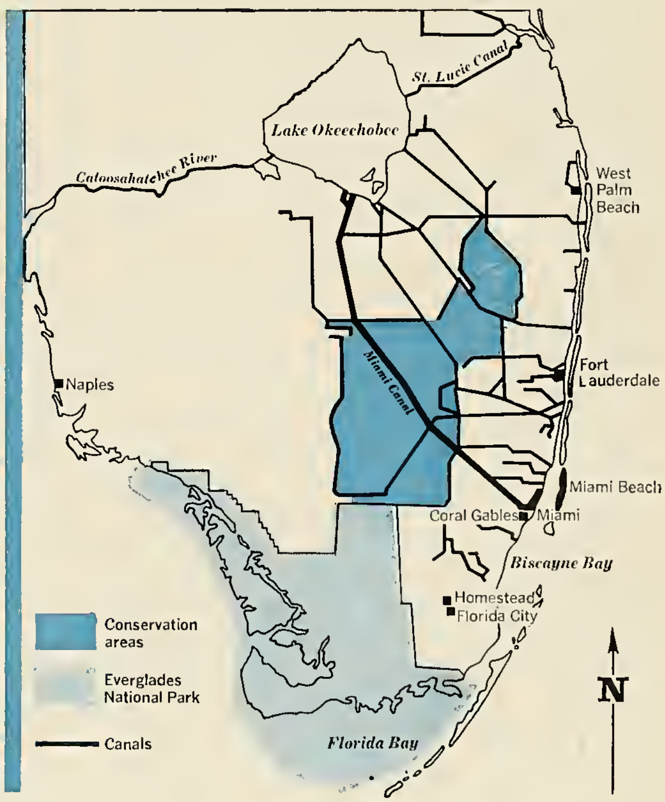
such additional pumping may cause further salt-water intrusion. Hopefully, the situation will not be as bleak as these estimates may suggest. Water is a reusable resource, and advanced technology and enlightened water management should be able to insure a continuing supply of fresh water in southern Florida.

The water situation of the Everglades National Park is also causing great concern. At the southern periphery of an extensive hydrologic system that furnished fresh water to southern Florida, the Park has depended on rain water as well as on water that flowed into it from the north. In December, 1962, the southern perimeter levee of the conservation areas was completed, thus establishing for the first time a permanent obstruction to the southward flow of water to the Park. Previous hydrologic records collected by the U.S. Geological Survey indicate the enormous amounts of water involved. For the ten years prior to 1962, flow into the Park through the Shark River Slough averaged about 250,000 acre-feet per year. The flows varied seasonally: lowest flows occurred in May and averaged 14 million gallons per day; the highest occurred in October and averaged 660 million gallons per day. The flow to the Park is normally 40 per cent of the total southward flow across the Tamiami Trail east of Monroe.

The need for water from the north to maintain the traditional ecology of the Park may be inferred from data on evapotranspiration. During a drought in May, 1962, when the only movement of water through the Park was natural seepage under the levees along the northern Park boundary, there existed in the southeastern part of the Park an area of roughly 75 square miles where water levels had fallen to 1.5 feet below mean sea level. Records of water levels in and near the area indicated that the water levels during this period fell at an average rate of more than ½ inch per day, primarily as a result of evapotranspiration. For the 75-square-mile area, such water loss amounted to 432 acre-feet, or 141 million gallons, per day—an enormous amount. The quality of water during the same May, 1962, drought provides further evidence of the freshwater need of the Park. The water-level depression that occurred in the southeastern part of the Park caused underflow in the ground water to that area from a seaward direction, as well as from the north. As a result, salt water moved inland through the limestone aquifer. Even twenty miles inland, chloride concentrations as high as 1,000 parts per million were detected. This same concentration—four times saltier than normal drinking water—moved inland to within five miles of Homestead.

Since December, 1962, when the last conservation area was completed, water releases to the Park have been irregular and inconsistent. For example, in April, 1965, the Park suffered from drought. During that month, releases to the Park from the limited storage totaled a meager 140 acre-feet of water. At this same time, it was found necessary to lower the level of Lake Okeechobee in advance of the coming rainy season. Water was consequently released directly to the sea via canals. More than 280,000 acre-feet were shunted to the sea, enough to supply the Park for an entire year. Amid the protests over this waste of urgently needed water, the flaw in the flood control system became obvious. It was impossible to move excess water from Lake Okeechobee to the Everglades National Park under the existing canal system without also pouring it across the farmlands in-between.

Efforts to work out more satisfactory schedules of releases to the Park have recently been intensified. Canals connecting Lake Okeechobee with the conservation areas are being enlarged to permit greater, more rapid



flow of water to the south, and emergency pumping has been used as a temporary measure to move the water more rapidly from one conservation area to the next. Nevertheless, the basic problem still remains: because of the extremely flat land it is almost impossible to move water quickly and efficiently from one part of the Everglades to another. Moreover, the effect of water releases on the flora and fauna is still incompletely known. Too much water released into the Park during an abnormally wet season, for example, may result in conditions as severe as those caused by drought.

The only definitive study of Everglades vegetation was made more than twenty years ago by J. H. Davis; another study by W. B. Robertson described the role of fire. Other ecologic and hydrologic data have been scarce. Perhaps the most significant hydrologic data available are those collected since 1939 on the flow across Tamiami Trail, and those from the rudimentary network of observation stations established south of the Trail since 1952. These collect data on water-level fluctuations, changes in water quality, and losses by evapotranspiration.

In recent years, the U.S. Geological Survey has expanded its program of data collection in hydrology and has initiated new studies in hydrobiology. One such study, conducted co-operatively with the National Park Service, involves the efforts of M. C. Kolipinski to find indicators of the abundance and well-being of the aquatic populations of the area. This is being accomplished by systematic sampling at several typical alligator holes and, during the wet season, at selected open Everglades sites. Although the study has been in progress for only one year, several indicators—killifish, mosquito fish, gar, bream, fresh-water shrimp, and dragonfly nymphs—have been identified and selected for regular monitoring. Future efforts will attempt to assess the roles of these indicators in the Everglades food chain and the effect of water levels on their abundance.

Plans for mapping the Everglades are also in progress. Because of the uniqueness of the area—the flat topography and lack of cultural features—normal methods of cartographic mapping cannot be applied successfully. So far, only three standard 1:24,000 scale topographic maps have been prepared of the Everglades area. With the usual cartographic symbolization and a five-foot contour interval, these maps show not more than one contour line per sheet in the Everglades, and the swamp symbol covers as much as 90 per cent of the sheet. Research is now being conducted on the development of a photo-image map that will be more meaningful. The photomap is produced from two negatives: a photo-tone negative that captures all the imagery of, say, clumps of vegetation but shows it in a subdued tone, and a photoline negative that captures only the edges of the images and that is similar in appearance to a line drawing. The end result gives a fairly accurate picture of the lay of Everglades vegetation.

Photography from orbiting satellites may become important to future studies. Orbital photography from a proper altitude could provide a single photograph of the Everglades at one instant in time and at a single angle of sun illumination. This overcomes the disadvantage of aircraft photography, which is done under varying sun angles, thus making interpretation of the photography more difficult. In addition, photographs obtained seasonally from an orbiting satellite would allow rapid over-all assessments of changes in vegetation and inundation resulting from natural and man-made causes.

An electric analogue model of nearly 2,000 square miles of the Biscayne aquifer is also under construction. Because of the similarity between the flow of electricity through a conductor and the flow of water through an aquifer, a network of resistors, capacitors, and diodes is being constructed to duplicate the hydraulic characteristics of the aquifer, including the effects of control dams and levees. When completed, it will serve as a predictive tool for evaluating the merits of alternate water management plans.

Currently, hydrologic data are being collected at some seventy sites in and around the Everglades. Flow in both the natural streams and canals is measured at more than twenty-five sites where continuous records of water level are recorded and translated into quantities of flow. Ground-water levels are read at approximately one hundred observation wells for information on the hydrologic status of the Biscayne aquifer. Water samples are also obtained on a systematic basis and analyzed for salinity and other water quality parameters. These data provide the basis for all studies of the water resources of southern Florida.

Many hydrologic questions still remain unanswered. For example, how much fresh water drains through the Everglades into the Shark River and other estuaries of the Gulf of Mexico? Although the historic flow into the Everglades National Park through the Shark River Slough has been established as a quarter-million acre-feet of water per year, further study is needed on the manner in which regulated releases are made from the conservation areas. Releases based on monthly or seasonal averages may be satisfactory. On the other hand, as previously pointed out, the role of severe flood and drought on the ecology of the Everglades is poorly understood. It may be that occasional flood and drought are necessary to maintain the present biological character, and these may need to be programmed into a schedule of water releases.

Another unanswered question relates to the ecotone. How does the fresh-water outflow across the Everglades affect the line of demarcation between the brackish-water marshes with their dwarf mangroves and the fresh-water saw grass environment? It is likely that a cessation of seasonal fresh-water outflow could cause an inland penetration of mangrove and brackish water far beyond its present limits. Such penetrations have often been observed in the past but never adequately measured.

It is obvious that much research will have to be conducted if we are going to answer any of these questions with intelligence. Until water problems—and in the Everglades that also means ecological problems—are thoroughly understood, it will be impossible to fully solve them.

Drainage canals course through the Everglades in foreground. View looks eastward, toward Palm Beach and the Atlantic.

SKY REPORTER

The first major Leonid shower since 1932 may occur this month

By Thomas D. Nicholson

The reader may imagine a constant succession of fireballs, resembling rockets, radiating in all directions from a point in the heavens . . . some were points but others were larger and brighter than Jupiter or Venus; and one was nearly as large as the moon. The flashes of light were so bright as to awaken people in their beds." These are some of the words that were used to describe what appeared in the sky during the night of November 12, 1833. They are quoted from an account by a mature and reliable eyewitness, Professor Denison Olmstead of Yale College.

Apparently it was a clear, cool evening over most of the eastern United States on that autumn night. Then, out of the starry sky, there burst literally a rain of meteors, described by many as "falling from the sky like snowflakes." In Georgia the display began early in the evening, about 9:00 P.M., reached its peak about 2:00 A.M., and faded before dawn. Farther north, at West Point, N.Y., and at New Haven, Conn., the display did not begin until about 5:00 A.M., quickly reached its peak of intensity, and had begun to diminish by 6:00 A.M. One observer at Boston, Massachusetts, had the presence of mind to try counting and reported 650 meteors seen in perhaps one-tenth or less of the whole sky in a period of 15 minutes. A reliable observer, H. C. Twyning at West Point, estimated that there were at least 10,000 bright meteors per hour at the height of the storm.

The great meteor storm of 1833 burst upon a world unsuspecting, and largely ignorant, of such a possibility, yet the records, after later study, showed that it could have been expected, if not actually predicted. The fault probably lay as much with astronomers as with anyone, for until only a few years before, they had refused to believe that meteors—those bright streaks of light so commonly seen in the night sky—could be produced by an extraterrestrial source. The meteor display of November, 1833, dispelled all doubts. Many observers clearly reported that the meteors seemed to emanate from a region within the constellation Leo and that, as Leo moved slowly westward during the course of the display, the radiant point moved with the constellation. Named for the direction among the stars in which the radiant point appeared, the Leonids sparked the beginning of an intense study into a new field of astronomy.

We know today that many meteor showers occur annually. Although perhaps only ten or so are well known and produce enough meteors to be worth watching for, dozens of different showers have been identified. They are caused by streams or swarms of particles that travel around the sun in more or less well-defined orbits, crossing, at least at one point, the orbit of the earth. As the earth revolves around the sun, each year, it reaches its encounter with each stream at the same point in its orbit and, as it runs through the orbit of the stream, scoops into its atmosphere some of the particles that make up the swarm. These particles, all traveling on parallel paths around the sun, enter our atmosphere from the same direction—the same point among the stars. However, as the particles hurtle through the air, the effect of perspective makes it appear that they radiate away from a point, or region, in the sky. Thus this point, or region, is known as the radiant of the shower, and its location among the stars gives the shower its name. Meteors of the Leonid shower appear to radiate from a region in Leo: the August Perseids from a region in Perseus; the April Lyrids from a region in Lyra.

The source of the particles that make up a meteor stream was identified by the famous Italian astronomer G. Schiaparelli (of Martian *canali* fame) in 1866. In that year, he established the identity of another famous shower, the August Perseids, with the orbit of a comet that had appeared in 1862. In the same work, Schiaparelli published his calculations for the orbit of the stream that produces the Leonids, and this soon was identified with the orbit of another comet known as 1866 I. In both cases, comets and meteor streams were found to be following nearly identical orbits, and subsequently other matched comet and meteor stream orbits were found. Although all known meteor showers have not been associated with known comets, any more than all comets have been identified with meteor streams, the relationship seems clear. Meteor streams probably represent debris left behind in their orbits by comets that approach the sun or the larger planets.

While the famous shower of November 12, 1833, may have been the beginning of serious investigation into meteor astronomy, it was neither the beginning nor the end of the history of the Leonid shower. After the event had occurred, reports were found in which ship captains and observers in Europe and Asia had described large numbers of meteors on November 13, 1831, and again on November 12 and 13, 1832. Other accounts were later brought to light of a brilliant shower of meteors seen from the West Indies and the Gulf of Mexico on November 12, 1799. In the years following 1833, many astronomers investigated the history of November meteors in ancient documents, and succeeded in tracing accounts of the Leonids as far back as A.D. 585. The his-

An unusual photograph shows a brilliant fireball streaking across sky as exposure was being made of Great Galaxy in Andromeda. Picture was taken at the Prague Observatory.

Sketch of the great Leonid shower of the night of November 12, 1833. Visible throughout the eastern United States, it was the first such shower to be identified by its radiant.

Accounts of the Leonids have been traced as far back as A.D. *585. Although spectacular, the shower predicted for 1867, shown above, was not as strong as the shower of 1833.*

tory strongly suggested that better-than-average displays occurred in periods of 33 or 34 years. Thus great storms of meteors had occurred in November at these intervals, and they could be expected to continue occurring as long as the meteor swarm remained intact. Apparently there was a dense cloud of matter revolving around the sun in a period subsequently established as 33.25 years.

BASED on the history of the Leonids and their calculations of its orbit, astronomers predicted that another major shower would occur in 1866 or 1867, and indeed it did, although it was not as spectacular—according to the accounts—as the shower of 1833. The hourly rates for a single observer were reported to be 5,000 on November 13, 1866; about 1,000 on November 13, 1867; and again about 1,000 on November 13, 1868.

The return of the shower was anticipated again in 1899. In the intervening years, the Leonids had produced only modest numbers of meteors, about 30 to 50 per hour at maximum. But 1899 was another year in the cycle, and rather wide publicity was given to the possibility that it might bring another display such as was seen 66 years before. Unfortunately, it did not materialize, and the faith of the public in the infallibility of astronomical calculations was rather badly shaken. In fairness to astronomers, however, there were some cautions issued before the anticipated event. Calculations showed that the swarm of particles could pass sufficiently near the orbit of Jupiter so that the particles could be deflected into another orbit.

Following 1899, interest in the Leonids never revived, not even in 1932, when another year in the cycle came due. That year a good display was produced in Europe, where up to 250 meteors per hour were counted, but nothing comparable to the former great storms.

Now, again, in 1966, the cycle falls due once more. What will it produce? To be on the safe side, we should predict no more than the usual 30 to 50 meteors per hour of the Leonids in their better years. But there are a few signs that it could be more interesting. Strong showers, with hourly rates of up to 120 meteors, were reported in November, 1965, from widely separated locations, including Hawaii, Australia, and southern United States. From the Smithsonian tracking station in Hawaii came reports of Leonids as bright as magnitude −5 (brighter than Venus at its best), indeed bright fireballs, with trains lasting several seconds. Transatlantic pilots reported frequent fireballs, at times several in the sky together. These reports are reminiscent of the brightness, if not the numbers, of the objects seen in 1799 and 1833.

It could well be that we may see, this November, another interesting, if not spectacular, Leonid display. If so, the key date will be November 16, from about midnight (when Leo is up in the east) until dawn. The crescent moon will be long since set by then, and conditions—except possibly for the weather—should be ideal. If you are looking, you should certainly see at least several dozen meteors per hour in the eastern sky.

DR. NICHOLSON, the regular author of this column, is also Chairman of the AMERICAN MUSEUM-HAYDEN PLANETARIUM

THE SKY IN NOVEMBER

Last Quarter	November 5, 5:18 P.M., EST
New Moon	November 12, 9:26 A.M., EST
First Quarter	November 19, 7:20 P.M., EST
Full Moon	November 27, 9:40 P.M., EST

TIMETABLE

November 1	10:00 P.M.
November 15	9:00 P.M.
November 30	8:00 P.M.

(Local Mean Time)

November 5: The weak, broad meteor shower known as the Taurids reaches maximum, but the early morning moon will disturb observations.

Jupiter and the last-quarter moon rise almost together in this morning's sky, with Jupiter some distance below the moon.

November 6: Mercury, rather poorly located in the evening sky, becomes stationary in right ascension and begins to retrograde. It goes through inferior conjunction on November 17 and passes into the morning sky.

November 8: Look for Mars, a reddish starlike object about magnitude +1.6, to the right (west) of the rising crescent moon in this morning's sky. Coming into view about two hours after midnight, Mars and the moon move up the southeastern sky together, slowly separating.

Venus, at superior conjunction, passes behind the sun, leaving the morning sky and becoming an evening star. Don't expect to see it in the evening, however, until late January of next year.

November 12: A total solar eclipse occurs in South America. The rising sun will be partially eclipsed for viewers in southern Texas, Mississippi, Alabama, and Florida.

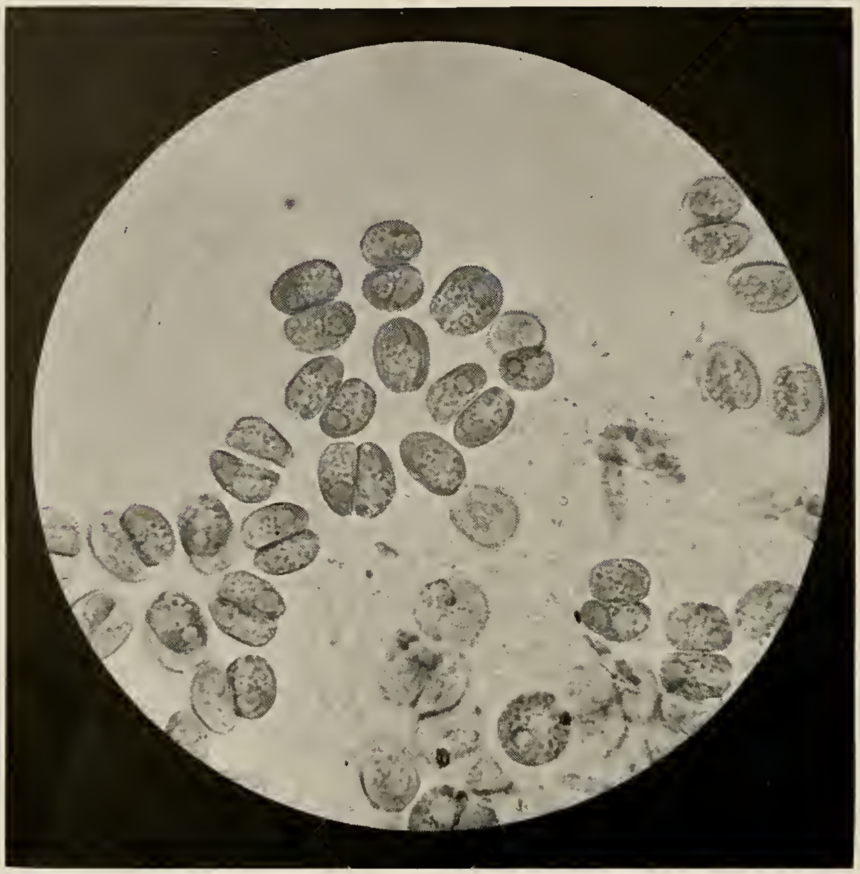
November 14-17: The Leonid meteors return, reaching maximum on the evening of the 15th/16th. This may be a good year for the famous Leonids, which produced the great storm of 1833 and major showers in 1866, 1867, and 1868.

November 21: Jupiter is stationary in right ascension and begins to move retrograde through the faint stars of the constellation Cancer.

Saturn comes into view high toward the south this evening, just above and to the left of the gibbous moon, but the moon will slowly shift to the left beneath the planet. Conjunction is about 9:00 P.M., EST. Retrograding from Pisces into Aquarius since July, Saturn resumes direct motion toward Pisces on November 27th.

All Month: Mars and Jupiter are both visible from about midnight until dawn, Jupiter very bright in the faint stars of Cancer, Mars rather faint in Leo. Saturn can be seen from sunset until after midnight.

Some Symbionts of the Sea



These cells, taken from the tentacle of an anemone, are symbiotic algae and are found in various forms of marine life. They play a role not yet fully understood.

Current research shows that algae living within the tissues of many marine organisms play an important function in ocean life

by HUGO FREUDENTHAL • JOHN LEE • JOHN McLAUGHLIN

In the biological world, life is largely a business of preying and being preyed upon; examples of co-operation are comparatively rare. There are, of course, some organisms that, in the course of evolution, have overcome the defense mechanisms of others and have become parasites living at their hosts' expense. This is, in itself, a delicate relationship, for an overly voracious parasite may eliminate its host, and thereby its own niche in the world.

There is a fine distinction between parasitism and co-operation, or symbiosis. No host gains any advantage from harboring a parasite. Symbiosis, however, is of mutual advantage and is perhaps an even more delicate matter. Imagine, for example, the subtle evolutionary steps that led to the appearance of lichens, a mutually beneficial combination of fungi and algae that forms the beautiful and tenacious plants that are commonly found growing on bare rocks or trees.

One might say that some algae have evolved with a considerable symbiotic potential, for there are a number of instances—on land, in fresh water, and in the oceans—where algae have been found living in mutually beneficial relationships with other organisms. As biologists probe further and further into the nature of marine life, particularly into the complicated ecology and productivity of the oceans, these instances of algal symbiosis become all the more important.

In fact, many kinds of marine organisms harbor algae: among them are protozoans, sponges, flatworms, shellfish, and coelenterates, which include sea anemones, jellyfish, and corals. It is fairly well known, for example, that many of the reef-building corals contain algal symbionts. Dr. T. F. Goreau and his associates at the University College of the West Indies have studied the rate at which reef-building corals deposit calcium. They have found that ten times as much calcium is deposited in the

light as in the dark, and that corals without algae show a uniformly low rate of calcification. Clearly, the photosynthetic algae are an important factor in the life cycle of the corals and therefore in the unique marine habitat of the coral reef.

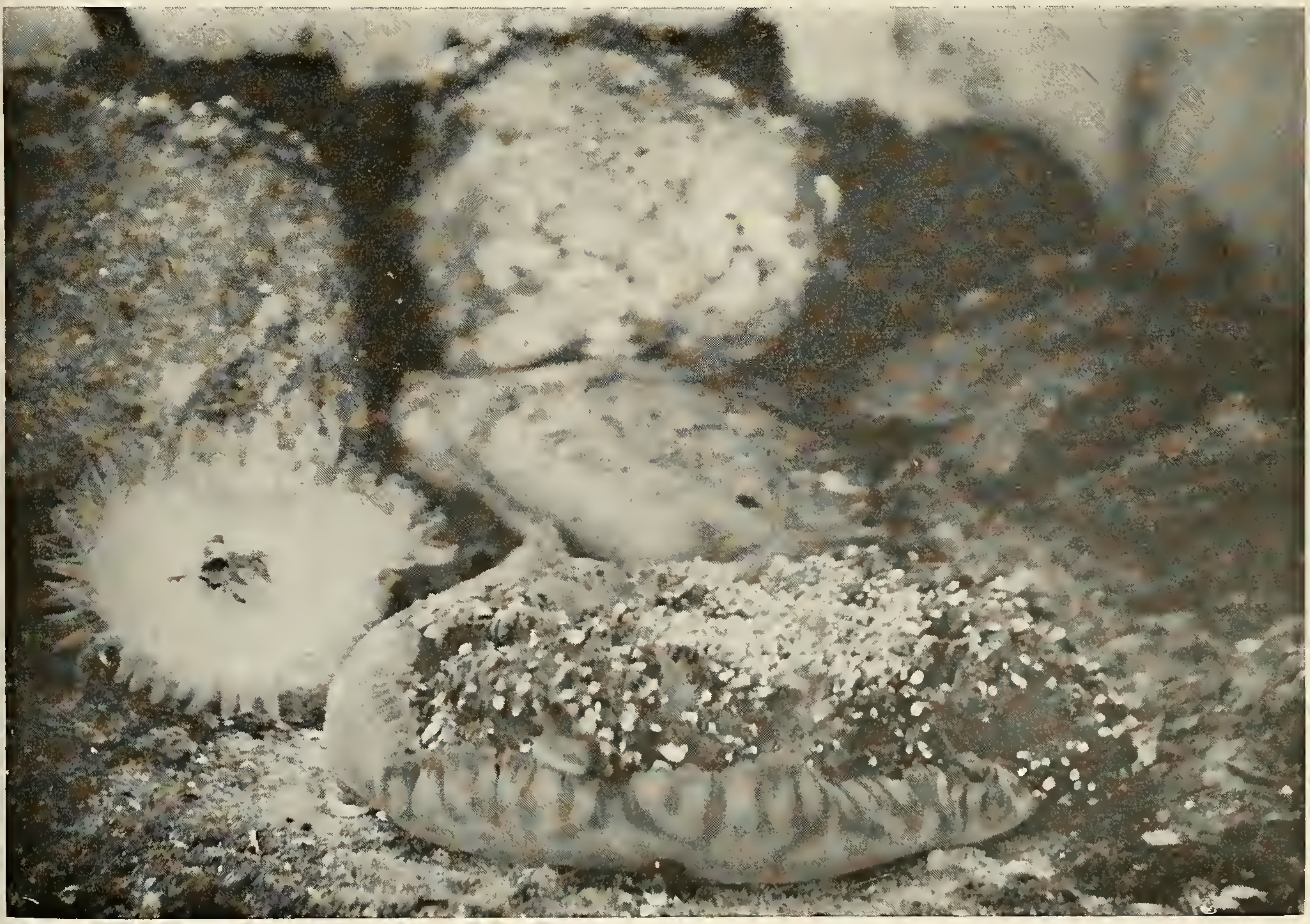
Another extensively studied algae–host relationship is that between the protozoan *Paramecium bursaria* and a species of the simple green alga *Chlorella*. The association is hereditary: a single host may harbor several hundred algae that are transmitted to both daughter paramecia at cell division. The algae and host have been grown separately in the laboratory, and it has been shown that the growth rate and maximum population density of *Paramecium bursaria* are increased by the presence of the algae. The algae seem capable of supporting the host for some time in light and in the absence of other food, allowing the host to become partially independent of its bacterial food supply, a situation with obvious survival value.

Scientists have studied still another symbiotic system, that of the green hydra, *Chlorohydra viridissima*, and a species of *Chlorella*. Radioactive tracers have shown that the algae photosynthetically incorporate carbon dioxide and release some of the resulting carbon compounds into the hydra tissue, where they are assimilated. When green and albino (algae-free) *C. viridissima* were fed daily on brine shrimp, both cultures grew at nearly identical rates. But in limited food cultures, the growth of the green hydra always exceeds that of the albinos. Under starvation conditions, the green hydra survived for two to three weeks, while the albinos succumbed in six to ten days.

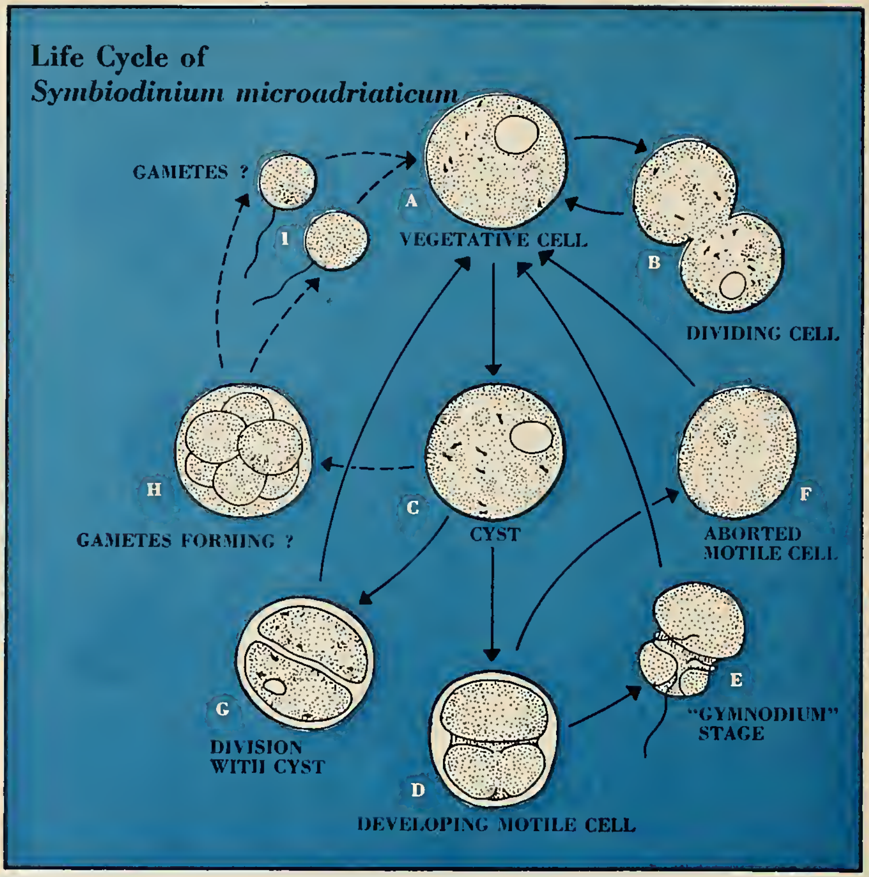
Recently, at the Haskins Laboratories and at The American Museum of Natural History, we have been studying the associations of algae with the marine coelenterates, particularly the "upside-down" jellyfish *Cassiopeia*. The first task of our research was to identify the algae that coexist with this coelenterate.

Certain of the algae that live with coelenterates are referred to collectively as zooxanthellae, because they have a predominance of brown pigment in their cells; the brown pigments in plants are frequently chemicals called xanthophylls. Green symbionts are called zoochlorellae, for the photosynthetic pigment chlorophyll. Earlier research had established that many of the algal symbionts of the coelenterates are dinoflagellates, microscopic plants common in both marine and fresh waters. Characteristically microscopic in size (7 to 500 microns), dinoflagellates have two flagellums: one trails behind the organism and the other is wrapped around it like a belt. The action of the flagellums causes the organism to spin as it swims forward, hence the name "dino" (spinning) flagellate. Dinoflagellates are a major component of the plankton of the sea and are important in the food chain. Some dinoflagellates are not so beneficial, however. For instance, there are those that cause shellfish poisoning and also produce the famous red tide, which causes massive mortality

Sunshine penetrates to jellyfish (foreground) in shallow waters off Florida's coast. This energy enables photosynthesis by yellow-brown algae, called zooxanthellae.



Zooxanthellae observed in the laboratory had this life cycle. Steps marked H and I are suspected, but unconfirmed.



in fish, spray-borne respiratory irritation to man, and tremendous economic loss. The poison produced by the red tide dinoflagellates is a powerful nerve toxin; one gram could kill about 5 million 20-gram mice in 15 minutes.

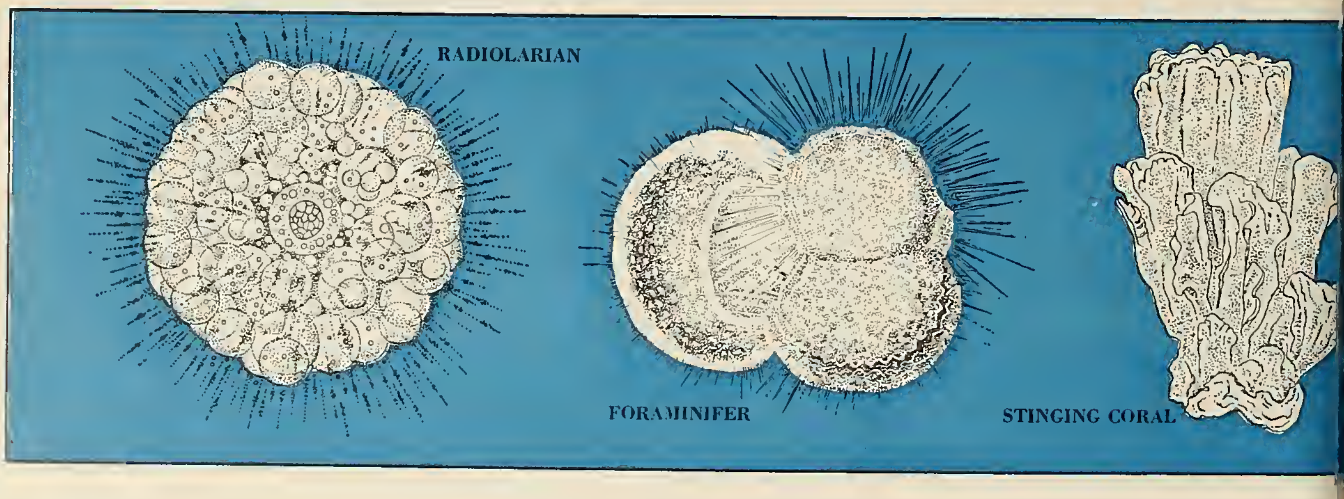
Among the dinoflagellates, almost every type of nutritional relationship can be found. Photosynthetic dinoflagellates are prey in the fresh-water and marine food chain. Some live by absorbing nutrients from their environment; others are predators. Some can live both as feeders and photosynthesizers; still others are parasites.

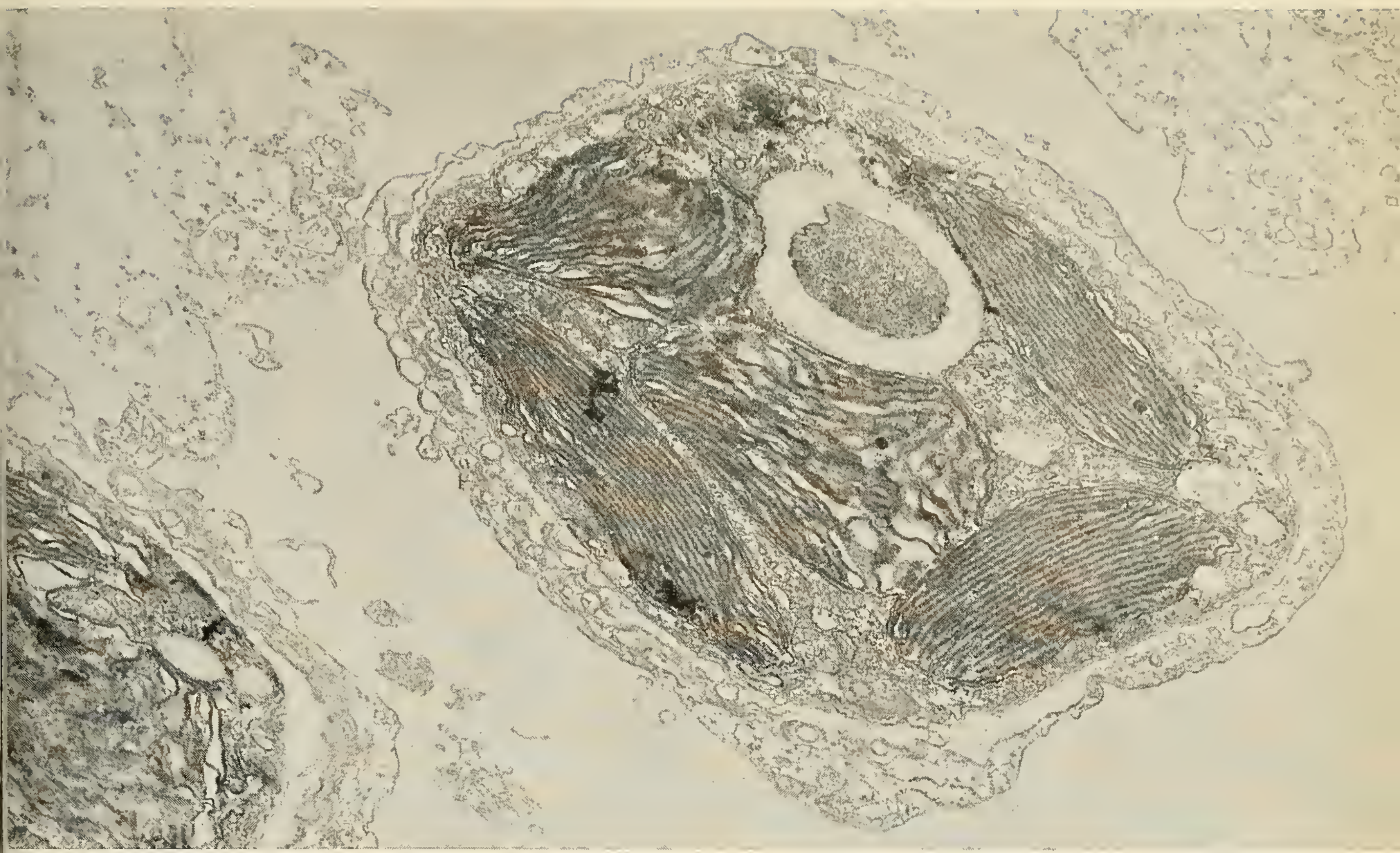
The task of identifying *Cassiopeia*'s symbiont was complicated by the fact that while in the host, the alga is in a non-motile, vegetative form—a spherical yellow-brown cell. Precise identification depended on seeing it in its motile, free-swimming form, if indeed there was a free-swimming form at all.

To resolve this, we needed a pure, or axenic, culture of the zooxanthellae. An axenic culture contains only one species of microorganism without any contaminant organisms: it guarantees that the results obtained relate solely to the organism under study and are not caused by the activities of some interloper. "Axenic" literally means without strangers.

In order to obtain symbiotic algae from the *Cassiopeia*, we homogenized the animal in a blender and then separated the freed algal cells from the "jelly" by spinning the homogenate in a centrifuge, washing the cells with sterile sea water, recentrifuging several times to remove as much of the bacteria and debris as possible, and then treating the cleaned, precipitated, non-motile algal cells with various antibiotics to kill any remaining bacteria. Even after these tedious procedures, an additional step was needed to obtain an absolutely pure culture. Using a hair-thin glass needle drawn on the tip of a small pipette and a dilute culture of the zooxanthellae in a slide under a stereoscopic microscope, a single zooxanthella cell was placed in a tube of sterile culture medium. This cell multiplied and became the ancestor of the many axenic cultures since

Among the many forms of marine life that contain symbiotic algae are a radiolarian and a foraminifer, two protozoans that are hosts to cyanellae (blue-green algae) and zooxanthellae. Various other protozoans contain zoochlorellae (green algae). Stinging coral and sea fan are coelenterates and are known to contain only zooxanthellae, one of the three symbiotic algae.





Electron micrograph reveals fine structure of the zooxanthellae. Dark striated bodies are chloroplasts, the parts that contain chlorophyll. In the vacuole at top is seen an assimilation body, the structure that serves the cell for the storage of carbohydrates.

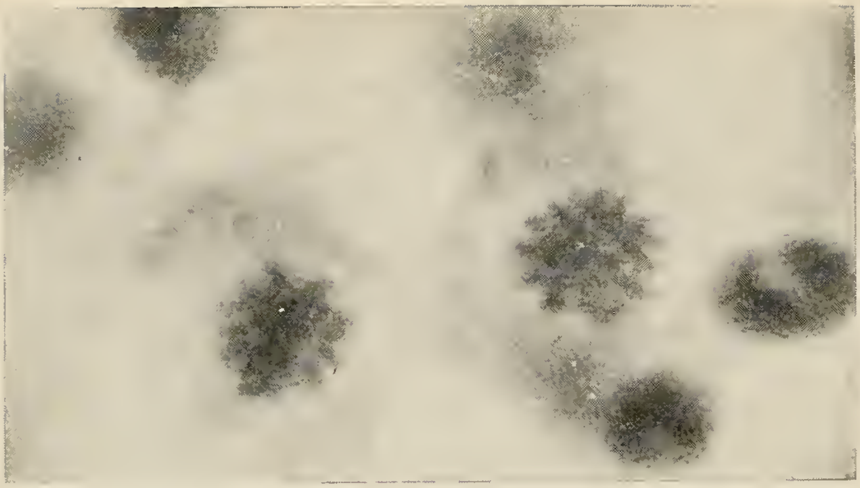
used in our studies of zooxanthellae.

The axenic cultures yielded two types of cells. One was the spherical, non-motile, golden-brown zooxanthella cell that lived in the coelenterate host. It grew on the walls and bottom of the culture tubes, or in floating mats. The second cell type, swimming in spiral courses through the medium, was a dinoflagellate.

In the axenic culture, the dinoflagellates would frequently lose their flagellums and become spherical in form. Then, occasionally, they would revert to their motile form. Thus was established the relationship between the zooxanthellae and the dinoflagellates; the zooxanthella was named *Symbiodinium microadriaticum*, reflecting its probable symbiotic nature in its generic name.

Like many other "simple" one-celled protozoans, the life cycle of *S. microadriaticum* is complex and involves many stages, all of which are adaptations to the changing environments to which it is exposed. During its life the zooxanthella may pass through both the motile and the non-motile stages, or it may be confined entirely to one or the other. The non-motile stage lives within the animal's cells or in the spaces between the cells. Here it reproduces, generally by binary fission, producing two daughter cells of equal size. It may, however, undergo formation of a reproductive cyst. In this case it divides within a cyst to form two, three, or four non-motile cells. When the cyst ruptures, the cells are freed to continue their vegetative existence outside the host. The organism may also undergo transformation within the cyst to form a motile, dinoflagellate type of cell, which then comes out of the cyst and swims off. It is presumed that the motile dinoflagellate is the stage that transfers from one coelenterate to another, although we do not know how it actually enters the animal; it is probably ingested. However, the zooxanthella (in its non-motile stage) may pass from one generation of the coelenterate to the next through the latter's embryonic stages; zooxanthellae have been found in coelenterate larvae.

At this point the question arises: What controls the transitions between the motile and the non-motile stages? In a culture tube containing mostly vegetative cells, motile dinoflagellates appear shortly after the illumination of the culture begins and reach their maximum number within a few hours. After that time they gradually revert to a dominant population of non-motile forms. There also is a chemical control: a higher concentration of calcium ions in solution favors the dominance of non-motile stages. As the calcium



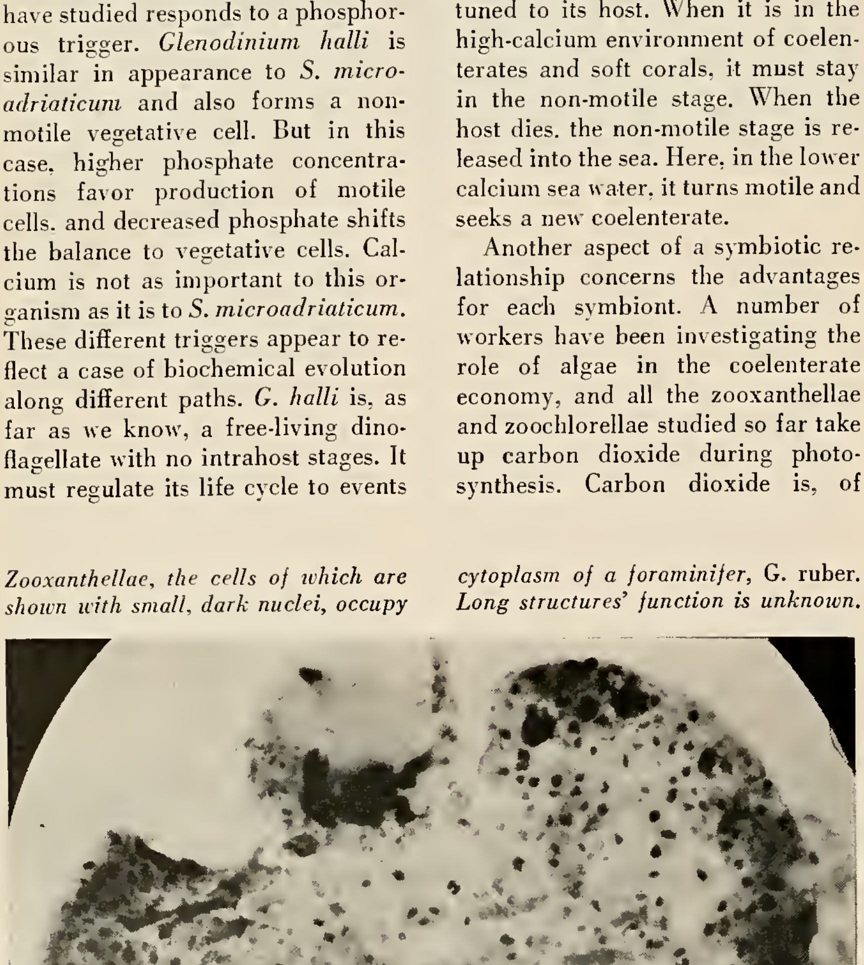
Photomicrograph shows the chromosomes of zooxanthellae, which are most often found in late prophase. This is an early stage in the division of nuclei.

concentration is decreased, the cells become predominantly motile.

Another dinoflagellate that we have studied responds to a phosphorous trigger. *Glenodinium halli* is similar in appearance to *S. microadriaticum* and also forms a nonmotile vegetative cell. But in this case, higher phosphate concentrations favor production of motile cells, and decreased phosphate shifts the balance to vegetative cells. Calcium is not as important to this organism as it is to *S. microadriaticum.* These different triggers appear to reflect a case of biochemical evolution along different paths. *G. halli* is, as far as we know, a free-living dinoflagellate with no intrahost stages. It must regulate its life cycle to events in the open sea, where the phosphate level may fluctuate considerably. But the zooxanthella's life history is attuned to its host. When it is in the high-calcium environment of coelenterates and soft corals, it must stay in the non-motile stage. When the host dies, the non-motile stage is released into the sea. Here, in the lower calcium sea water, it turns motile and seeks a new coelenterate.

Another aspect of a symbiotic relationship concerns the advantages for each symbiont. A number of workers have been investigating the role of algae in the coelenterate economy, and all the zooxanthellae and zoochlorellae studied so far take up carbon dioxide during photosynthesis. Carbon dioxide is, of course, produced by the respiration of the animal host, and is liberated into the surrounding medium. But the value of respiratory carbon dioxide to the symbiotic algae is difficult to assess. It is normally abundant in both sea water and fresh water, but it is possible that high concentrations of zooxanthellae in an animal cause a local deficiency of carbon dioxide. If this is the case, photosynthesis might not be possible without the additional carbon dioxide provided by the host's respiration.

Zooxanthellae, the cells of which are shown with small, dark nuclei, occupy cytoplasm of a foraminifer, G. ruber. *Long structures' function is unknown.*

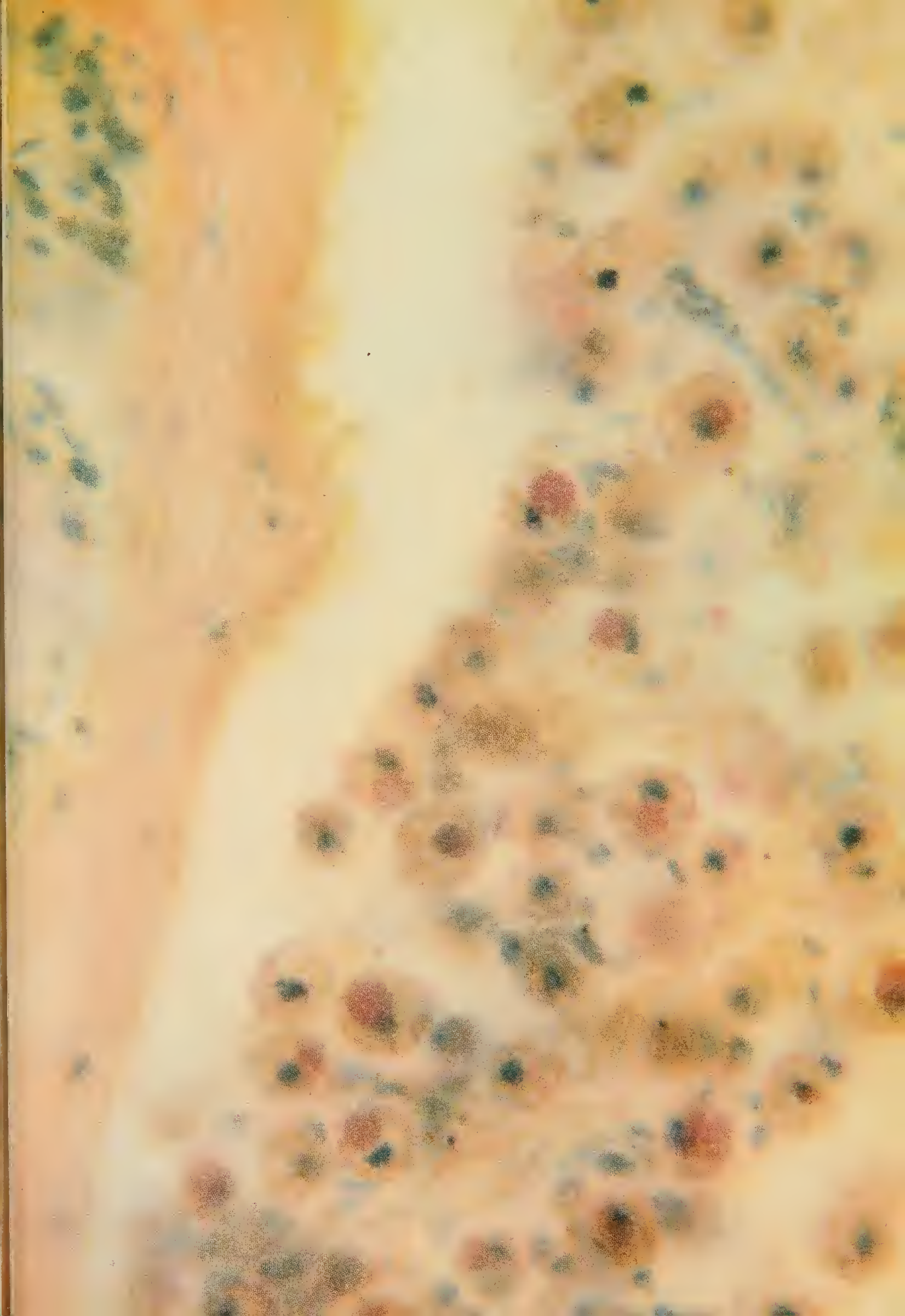


We have recently been studying the cytology of the zooxanthellae of the coelenterates, as well as those of certain planktonic foraminifera, in the hope that we can learn more about the complicated biochemical relationships that exist between the algae and their hosts.

The zooxanthellae that live in certain planktonic foraminifera such as *Globigerinoides ruber* undoubtedly influence the life histories of these marine protozoans and their effect on the total productivity of the sea. With the help of Dr. Allan Bé and his group at Lamont Geological Observatory we are studying these zooxanthellae, and we are fairly certain that they are not the same species that occur in the sea anemones or medusoid coelenterates. However, the actual identification of the species is largely based on examining the motile cell, as was the case with *S. microadriaticum*, and we must therefore get the algae in culture. Soon we should be able to isolate its zooxanthella, identify it, and do the much-needed physiological studies.

There are many unanswered questions about the interplay between algal symbionts and their hosts. With the rapid advance of culture techniques and physiological technology we can look forward to a better understanding of the genetics, evolution, and subtle harmony between these sea-going symbionts.

In photomicrograph, right, cytochemical preparation has stained certain types of protein yellow. A characteristic of zooxanthellae (at right) while in hosts is that their chromosomes are condensed in the nucleus; these are stained green. Chromosomes in some cases are cupped over assimilation bodies, which stain red; also "jelly" of Cassiopeia *(host, at left) stains red.*



ALLIGATOR

Symbolic of the Everglades, this reptile exerts a steady influence on surrounding flora and fauna

by Patricia Caulfield

The female alligator firmly grasped the clump of saw grass near its base, then pulled and twisted it free. She dragged the grass and the muddy ooze clinging to its roots twenty feet to a heap of previously uprooted vegetation and dropped it; then, pressing with the full weight of her body, she packed the grass on the mound. When the mound was about five feet in diameter and two feet high, she stopped working and walked around it. She then climbed the mound and painstakingly hollowed a depression in the center, forcing the grass and mud back and up the sides with her feet as she worked her body around in a full circle. When the edge of the mound was twelve inches higher than the center, the nest-maker climbed down, waddled off, and disappeared into the surrounding saw grass.

Shortly after dawn the next day she returned, lay across the hollowed depression, and deposited her eggs, pausing only a few times in the process to rest. She laid 24 eggs in all, white ellipsoids about 2 inches long and 1½ inches in diameter. The eggs were relatively small, as was the size of the clutch. The alligator was young —at approximately eight years she was only about six feet long and weighed perhaps ninety pounds.

To cover the nest, she lashed the nearby saw grass with her tail and picked up and carried the grass cuttings in her mouth. These she deposited over the nest, repeatedly pressing them down to smooth the nest's surface. When she finished, she retired to her den in the bank of the nearby pond, which may have been created some 10,000 years before by another alligator.

While I didn't witness these events, I have reconstructed them to explain the behavior of the small female alligator that we came upon when we entered her pond in the Everglades. She was sunning herself on its edge, lying on bent-over saw grass. We moved the boat in closer, and I took pictures. The alligator stared. One of my companions threw a flower at her. She snapped, and so did I. Then she moved into the water and swam swiftly around the pond. Wild alligators are quite shy of man. With the occasional exception of crotchety old bulls and of females guarding their nests or young, alligators will flee and hide rather than stand ground.

We left the female alligator in peace after about twenty minutes. Assuming that all went well with her, she probably continued to guard her nest, keeping it properly moist by splashing water on it with her tail or by urinating on it if the water table dropped too low. Heat generated by the rotting vegetation would keep the eggs warm. After approximately sixty-three days, the alligator young (partially in their eggs) will call out, and the mother will remove the layer of grass and mud that covers them. Using the egg tooth at the tip of its nose to extricate itself from the egg, each 8-inch-long infant will remain in the nest at first, with the yolk sac that nourished it not yet completely absorbed. Within a few days, the sac disappears. By that time, the young have left the nest and followed their mother to her pond and den. For at least one season—if not two or three—they remain with the mother, who continues to protect them from harm, which comes mostly in the form of the larger wading birds, raccoons, bobcats, and even adult alligators. But when the young alligators grow to three or four feet in length, they have few enemies—only other alligators and man.

During the wet season in the Everglades, when the water, a foot or more deep, flows slowly south through the saw grass, alligators range far from their dens. But in the dry season, normally January to late May or June, they stay closer to their ponds, which are then the last reserves of available water.

Except for deer, who quench their thirst with dew, all the animals in the glades are heavily dependent on the ponds. Raccoons and bobcats come to them to drink; birds use them as feeding and watering places; most of the fish that are able to survive droughts and that subsequently restock the waters of the Everglades collect there.

The ponds are not geologic accidents. They were created and are maintained by the alligators, which also dig dens in their banks. To make a pond, an alligator uproots grass and mud, slashing with its powerful tail, digging with its hind feet, and carrying debris away in its mouth. It digs its den, which is usually floored by the limestone that is several feet under the surface of the soil, in the same way, often tunneling as far as twenty feet from the pond. The den is simply a tunnel, with a space at the end large enough to permit the alligator to turn.

The alligator continues working on the hole while it lives there, deepening it, widening it, keeping it free

of weeds. Most of the muck and chopped organic matter floats away, but some lodges in the grass at the pond's edge. From airborne seeds, willows take root in the edges; eventually the pond is rimmed with willows. As the trees grow, their trunks, leaves, and roots present surface resistance to the slow southward flow of Everglades water, causing sediment and organic materials to collect around them. On this mound the trees shed their leaves and dead grasses accumulate. After many years of such litter deposits a dryland island builds up in the river of saw grass. Called either a head or a hammock, the island's soil elevation is no more than a few inches or feet above the roots of the surrounding saw grass. But it is high enough for trees to root and for the establishment of an ecologic community that is completely different from the surrounding, grassy river.

Usually only one bull, one cow with young, or a number of adolescents reside in a single alligator hole and den at one time. Alligators are not overly social. Occasionally there are two dens in one large pond; even more rarely two congenial bulls may share one den. When conditions become very dry, the water table drops below the bottom of many of the holes. The alligators then trek miles overland to find standing water, and the deepest pools become crowded. As the food supply dwindles under these overcrowded conditions, the alligators, like many other animals, become cannibals. The larger eat the smaller, and also slash away at each other, sometimes chomping off a limb or part of a tail. Since the driest period often coincides with the mating season, it is hard to know how much of the alligators' aggressiveness comes from hunger and overcrowding, and how much is the result of sexual competition.

Alligators are territorial. A single bull will claim several square miles as his domain. During the mating season he visits the females who reside in the area, remaining with each for several days and running a regular route between them. When another male enters his realm and challenges his right to it, a fight may ensue. Often the combatants lock jaws. The stronger breaks the jaw of the weaker who, if he survives the battle, will be unable to seize food and is almost certain to starve.

Probably the most widespread recent outbreak of mass cannibalism among the Everglades alligators took place in Everglades National Park during the much-publicized 1965 drought. That spring, visitors observed such sights as a nine-foot bull swimming back and forth with a six-foot bull gripped firmly in his jaws. That drought was so severe that the Park Service blasted artificial survival holes in an effort to reach a van-

ishing water table. They airlifted alligators to them from dry holes.

Since the 1800's the alligator has been hunted for its hide, and in many areas of the Southeast where it once reigned, it has been exterminated. Because of the Everglades' inaccessibility, it was one of the alligator's last strongholds. As recently as the late 1950's, for example, observers flying over unhunted portions of the Everglades reported seeing hundreds of huge, old alligators, probably twelve feet and longer in length. Now it is difficult to locate even one such large specimen, in or out of the national park. At night poachers speed across the grasslands as fast as 100 mph in flat-bottomed air boats. They flash powerful searchlights to catch and hold the alligator's gaze. Then the alligators are shot. The hide on their stomachs, destined perhaps to become a pair of shoes or a handbag, is worth $6 per foot, untanned. It is likely that the price will soon go up.

Willows have gained a foothold around the edge of a recently formed alligator hole. Their leaves will become a major soil-building element.

In its pond in the middle of a willow head, an unusually large bull alligator devours an unusually plump fish.

Choice of telescopes

By James S. Pickering

The eye alone, without optical aid, is capable of seeing about 9,000 objects in the night sky, all but a few of them stars. This is the score under ideal conditions, for the eye is a feeble and inadequate instrument. Any help to the eye—even field glasses or the simplest telescope—will reveal marvels hidden by distance. There are few experiences as satisfying as the seeking and finding of the tiny image of an incredibly remote galaxy, a cloud of glowing gas, or a distant cluster of thousands of stars. Unfortunately, the telescope is like a musical instrument. Its use must be learned, and practice is a requirement for perfection. In this series, we will attempt to lay a foundation for this fascinating hobby.

There are three basic types of telescopes available to the backyard observer: the refractor, the reflector, and the catadioptric, which combines the features of the first two. Each type performs in accordance with the optical system it is based upon, but there may be variations in detail within each system.

Light is a versatile phenomenon. It is composed of energy waves of various lengths, and each wave of a different length produces a different color sensation on the optic nerves. Light is capable of being bent when it is allowed to pass from a transparent medium of one density into a medium of a different density; this bending is known as refraction. Longer waves of light are refracted, or bent, to a lesser extent than shorter waves. Light will also bounce from any surface it strikes, and the smoother and more highly polished the surface, the greater the amount of light that bounces; this is reflection. Light is reflected from a surface at the same angle at which it strikes the surface.

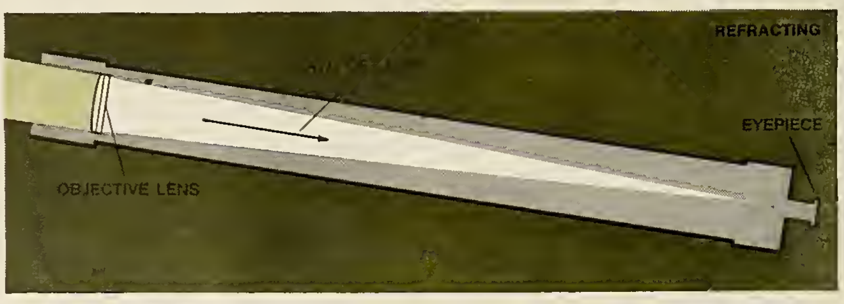
The Refracting Telescope

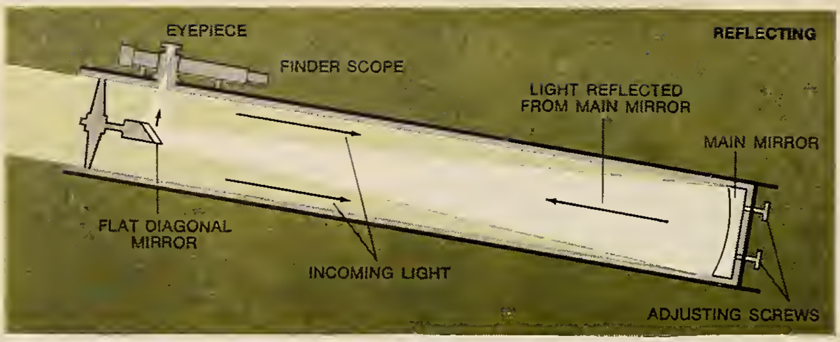
The light from stars and other luminous objects in the sky radiates in every direction, but even the nearest of these objects is so far away that we are able to consider this light as reaching us in parallel rays, rather than rays that diverge. A refracting telescope receives the light through a large compound lens called the objective, which is placed at one end of a hollow tube. This lens must be compound to insure that waves of light of every length are bent to the same extent, which does not happen with a simple lens. The two lenses of the objective are ground and polished to a special set of curves so that the entering light is refracted in such a way that all the waves of various lengths come together at one point behind the objective.

This point is the focus of the objective and is inside the tube. At the other end of the tube is a second combination of lenses, the eyepiece, or ocular. The ocular magnifies the image formed at the focal point of the objective. The eyepiece can be moved backward or forward to accommodate an observer's eye. He sees the magnified image and is in business.

The objective does nothing more than collect light and bring it to a focus. Obviously, the larger the objective is, the more light it can collect, and the fainter the objects it can bring into view. All the magnifying functions of a telescope are in the eyepiece. Because lenses are surfaces and not lines, the ratios of their light-gathering abilities are as the square of their diameters. A lens 4 inches in diameter will admit 4 times more light than a lens 2 inches in diameter, not twice as much. The average eye pupil is about 1/5 inch in diameter. The largest optical telescope, the Hale at Mount Palomar, has a 200-inch-diameter objective. Therefore, this telescope can gather about 1,000,000 times as much light as the average eye.

The distance behind the objective to the point where the admitted light is brought to a focus is the focal length of the objective and is expressed by a capital F. In small refractors, this focal length is usually about 15 times the diameter of the objective, a ratio that is known as the f-number of the lens, or the focal ratio. In most small refractors,





the focal ratio would be expressed as f/15. An objective lens marked 60 mm. will probably have a focal length of about 900 mm. A similar objective lens marked 2½ inches will have a focal length of about 37½ inches. (Dimensions of telescopes are sometimes expressed in inches, but more often in millimeters. There are about 25 millimeters to the inch.)

Eyepieces are, in a sense, tiny telescopes of short focal length. The focal length of an eyepiece is usually stamped on its barrel and is designated by a lower case f—as f24 mm. The magnifying ability of an eyepiece is the ratio between the focal length of the objective of the telescope and the focal length of the eyepiece used, or F/f. The focal lengths of eyepieces usually range from about 36 mm., or 1½ inches, down to 8 mm., or ⅓ inch. So, if the focal length of the objective is 30 inches and that of the eyepiece is 1 inch, that eyepiece will produce a magnification of 30/1, or 30 times—expressed as 30 power, or 30×.

It is obvious that eyepieces of different focal lengths will produce different degrees of magnification with the same objective. An eyepiece of ⅓ inch with a refractor of 30-inch focal length will have a power of 90. Hence, the best criterion for comparing telescopes is the diameter of their objectives, not the so-called power of the telescope. We read, unfortunately, advertisements for telescopes of "200×," but that expression is meaningless unless the diameter of the objective is known. There is a limit to the degree of magnification an objective-eyepiece combination will produce, and it is well to remember a rule of thumb covering this relation: The limit of magnification possible is roughly 50 times the diameter of the objective in inches. Thus, a 2-inch refractor will support a magnification of about 100 times. If the focal length of this refractor is about average (15 times the diameter of the objective—or 30 inches), the shortest-focus eyepiece it will accept will be about ⅓ inch, or 8 mm.

As magnification increases, the field of view of a telescope—the amount of sky shown and hence the amount of light admitted—shrinks. Many manufacturers of telescopes advertise 1-inch telescopes with 200×, which are useless except perhaps in observing the sun or moon.

A refracting telescope is usually mounted on a tripod whose legs may be adjusted to a convenient height for the observer, usually so that the eyepiece is at about eye level when the telescope is horizontal. An essential device for a refractor is a star diagonal, or zenith prism. This is a tiny elbow with a mirror inside it, which is inserted in the telescope between the tube and the eyepiece. It reflects the image at right angles so that the observer will not have to be a contortionist to use his telescope. Let's face the fact, however, that some unusual physical positions are necessary, even with the best equipment, but a star diagonal reduces them to a minimum.

The Reflecting Telescope

A reflecting telescope also receives light through a tube, but its main component—its objective—is a mirror placed at the bottom of the tube. This mirror, usually made of Pyrex with a surface coated with some highly reflective substance, is ground and polished to a special shape, a paraboloid. This paraboloid mirror brings light waves of all lengths to a focus at one point, high up near the upper end of the tube where the light enters.

The problem now is to examine this image. If it were attempted directly, the observer's head would be in the way of the entering light. A small mirror, optically plane, is placed inside the tube at its center, and is at an angle of 45 degrees with the plane of the objective mirror. This secondary mirror intercepts the cone of light reflected by the objective and diverts the last few inches of it at right angles toward the tube's wall. Here a hole is cut and the eyepiece placed outside the tube, near the upper end.

The focal length of a reflector is usually about 8 times the diameter of the objective mirror. The relation between focal lengths of objectives and eyepieces for reflectors is the same as that for refractors and produces the same power of magnification; and, of course, light-gathering ability depends on the diameter of the objective mirror.

It is dangerous to compare the two types of telescopes, size for size, but in

general, and with a great deal of mental hedging, a 3-inch refractor and a 6-inch reflector are essentially the same in performance. Each can conveniently be handled in a backyard and set up for an evening's observing. The magnifying ability of the refractor is slightly greater because of its greater focal length, while the light-gathering power of the reflector exceeds that of the refractor because of the larger diameter of the objective.

A star diagonal is not needed with a reflector because the position of the eyepiece (near the upper end of the tube) is convenient and will not require the contortions needed to use a refractor without a diagonal.

A reflector is also usually mounted on a tripod, but this is much lower than the tripod for a refractor.

Mountings

There are two general types of mountings for small instruments. The simpler of the two permits motion of the telescope in only two directions, up and down and sideways. This is the altazimuth mounting: from altitude, "vertical," and azimuth, "horizontal." The rotation of the earth, from west to east, makes the stars appear to move from east to west across the sky in smooth arcs. An altazimuth mounting requires that the telescope be moved in steps, horizontally and then vertically, to keep up with the motion of the star, so that it is not possible to hold the star continually in the field of the telescope.

The altazimuth mounting is, however, less expensive than the more elaborate equatorial mounting, easier to set up, and satisfactory for casual observing.

The equatorial mounting permits the telescope to be moved in an arc and thus allows the observer to follow the object he is observing for as long as he wishes. The telescope can be turned against the motion of the earth manually or by an electric motor or a clockwork drive.

An equatorial head requires a precise, level setting of the telescope tripod. To the top of the tripod is attached a base that carries the polar axis. This base must be level, and the polar axis is fixed to it at an angle that is equal to the latitude of the location of the telescope. The polar axis should point to true north. If it is properly set up, the Pole Star, Polaris, should appear in line with the upper end of the polar axis when the observer sights along the axis.

To this upper end of the polar axis, and able to rotate about it, is the declination axis. The telescope is attached to one end of the declination axis so that the telescope, too, may rotate about it, and there is a counterweight at the other end of the declination axis to balance the weight of the telescope. With an equatorial mounting, once an object is in the field of view, it can be followed by

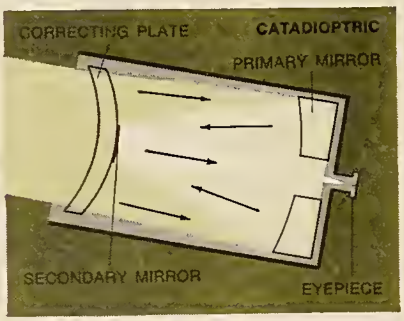
one continuous motion of the telescope.

It is obvious that an equatorial mounting is more elaborate and thus more expensive than an altazimuth mounting, but it is essential for any extended observation period of a single object and also for photography.

The Catadioptric Telescope

THE third general type of telescope combines the principles of the refractor and the reflector. The catadioptric telescope uses a concave mirror shaped like a section of a sphere. Such mirrors are easier and less expensive to make than the paraboloid mirror, but light waves of different lengths are not brought to a focus at one point when reflected from a spherical surface. To eliminate this difficulty, a correcting plate is placed at the upper end of the telescope tube, thus making it a closed system. The plate slightly alters the angles at which the light waves of different lengths enter the telescope and insures their reaching a focus at the same point.

The cone of reflection from the objective mirror is intercepted by a convex secondary mirror, often fastened to the bottom of the center of the correcting plate. This secondary mirror reflects the light back through a small hole in the center of the objective, and the image is examined through an eyepiece placed here. Since the eyepiece is placed at the lower end of the tube, as in the case of refractors, a star diagonal, necessary to avoid discomfort while observing, is built into the optical system.



The optical system of a catadioptric telescope allows the light reflected from the primary mirror to travel a greater distance than is indicated by the length of the tube, since the light is, in a sense, folded over. This system permits a long focus in a small, compact instrument and gives a high degree of magnification in spite of the shortness of the telescope tube. Catadioptric instruments are compact, convenient, and expensive.

The mounting of a catadioptric instrument is usually built in one permanent assembly with the tube, and the entire instrument is set on a sturdy table for use. The compact construction permits comfortable observing even though the eyepiece and star diagonal are at the lower end of the tube.

There are, of course, advantages and disadvantages for each type of telescope. The observer must decide for himself. Here are a few comparative factors on both sides of the ledger.

Refractor

ADVANTAGES	DISADVANTAGES
Upkeep zero. With a closed tube, good lenses will last forever.	Awkward. High mounting, long tripod.
Stays in adjustment.	Cost higher per diameter of objective.
Can be used as a terrestrial telescope.	Some color error. Increases with size.
Minimal temperature effects because of closed tube.	Long tube. Also increases with size of objective.
No central obstruction.	

Reflector

No color error.	Temperature effect; open tube.
Lower cost per diameter.	Adjustment and maintenance continual.
Convenient, low mounting.	

Catadioptric

Compact, convenient.	Higher cost per diameter.
Closed system. Stays in adjustment.	Requires extra table.

The cost of the refractor, leaving out all but the essential accessories, is considerably more than that of the reflector. A compound lens, made of the finest optical glass so that light may pass through it with the least interference, and requiring special professional skills to grind and polish at least four surfaces, costs much more than one piece of Pyrex, ground and polished to a paraboloid surface and suitably coated.

It is difficult to quote specific prices for the different types of each variety of telescope. A simple, 3-inch reflector—about the smallest objective that will give full satisfaction—equipped with the necessary complement of eyepieces, can be bought for under $100. A 6-inch reflector with the essential equipment costs from $200 up. The "up" can reach as high as you wish to go and can include a variety of luxuries.

A 2-inch refractor with an altazimuth mounting and the necessary accessories should cost about $75. A 3-inch refractor with an equatorial mounting and essential equipment will cost from $450 up.

In the next article of this series, we will discuss in detail the eyepieces best-suited for each type of telescope, and present more basic constants and some suggestions that will increase the pleasure of using small telescopes.

In his many years as Assistant Astronomer at the American Museum-Hayden Planetarium, James S. Pickering has taught countless amateurs how to get the most out of telescopic viewing of the night sky. He is the author of "1001 Questions Answered About Astronomy" and "Asterisks."

Continued from page 25

plores the forest from the humus on the soil to the green leaves and buds on the highest twigs, from the Pacific to the Atlantic, and from the cypress forests of the South to the North Woods. Platt's book is marred, however, by many misinterpretations—especially when he delves into tree physiology and anatomy—and contains a number of sensationalisms.

The most thorough and usable of the two geographic treatments is Hal Roth's *Pathway in the Sky: The Story of the John Muir Trail* (Howell-North). This 212-mile-long trail threads through the spectacular high country of the Sierra Nevada of central California. The book describes the history of exploration of the High Sierra, the period of the sheepmen, and a brief account of John Muir's life in the mountains. The main portion of the text consists of a series of essays on points of interest, ecological problems, or major species to be seen along different sections of the trail. I found the essays on the lodgepole needle miner—a small insect that kills whole forests of lodgepole pine—and on deer population problems to be especially interesting. The book is illustrated by many fine photographs taken by the author during his six trips over the Muir Trail. For those who will follow, it would have been of great interest to include a short statement on the cameras and films Mr. Roth used and on any special techniques useful to mountain photography.

Franklin Russell's *The Secret Islands* (Norton) is a chatty, often philosophical recounting of a tour of a number of small, little-known, and infrequently visited islands along the coasts of New Brunswick and Newfoundland. This book will have considerable appeal to anyone interested in the habits of waterfowl, for most of the text is devoted to observations of the local birds. The book also will provide good reading for anyone interested in a really novel vacation trip, far from the crowds.

Four titles are basic science presentations. By far the most novel botany book I have seen is *Adventures in Living Plants*, by Edwin Kurtz and Chris Allen (University of Arizona Press). By using imaginary pills, the authors "shrink" the reader to a size that permits easy travel through the tissues of a plant and describe the "thrilling" sites seen along the way. It is a "cute" approach, but the cartoons and humorous diagrams may lead the novice to great misconceptions, and while the text is wordy and childish, many of the concepts discussed are advanced. Each chapter includes directions for several demonstrations that will increase the reader's comprehension and perhaps dispel some of the misconceptions relayed by the text.

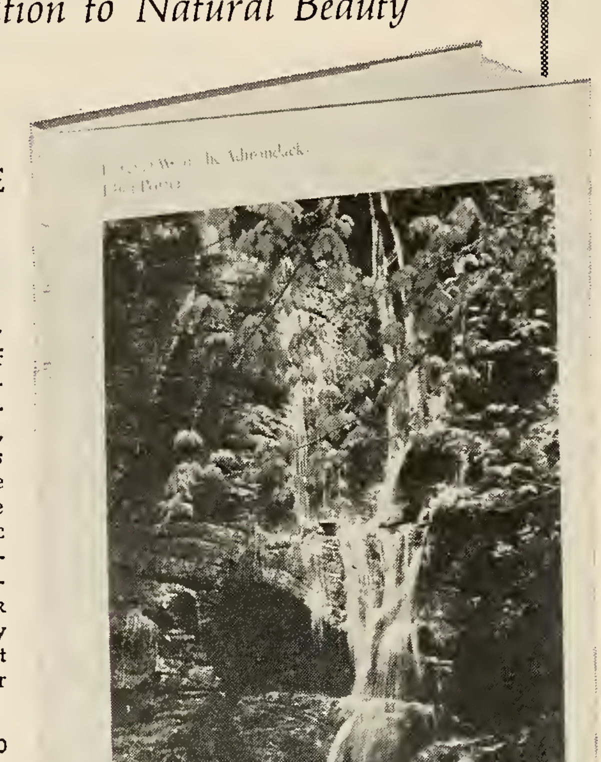
The Living Community, by S. Carl Hirsch (Viking), is an amateurish book on ecology that employs the "community approach." The text contains many vague statements and several incomplete case studies. A large portion of the book is a review of Darwin's life, the development of his theories of evolution, and descriptions of the popular and scientific reactions to his theories. Although the author has inserted a brief caution about teleological explanations, many of his own statements are teleologic. In short, there are several better-written books on ecology available.

A very limited segment of ecology is considered in *Partners in Nature*, by Ruth H. Dudley (Funk & Wagnalls). She discusses various symbiotic relations among animals, among plants, and between animals and plants. Although the subject is interesting, the text is suffused with anthropomorphisms, which detract from its educational value.

A careful reviewer can find minor errors in most books and almost always finds unscientific interpretations of animal and plant behavior in books written by laymen. There seems little excuse, however, for a book by a professional biologist to head the list of error-filled natural history books. Yet that is the rank I would assign to *The Amazing Seeds*, by Dr. Ross E. Hutchins (Dodd Mead). These errors begin on the first page of the text (mosses and liverworts are said to have probably been the first green plants) and are conspicuous throughout. The book is illustrated by many superb photographs by Dr. Hutchins that attest to his skill with a camera if not with a pen.

The remaining three books are on conservation topics. The most attractive to me is *Guarding the Treasured Lands: The Story of the National Park Service* by Ann and Myron Sutton (Lippincott). The Suttons, who met when both were employed as naturalists in Grand Canyon National Park, are well acquainted with the Park Service and the properties it oversees. The book presents a brief, but interesting and informative, history of the Service and accounts of the activities of naturalists, historians, archeologists and rangers. It will provide an excellent reference book for school libraries and should be read for pleasure, too.

Careers in Natural Resource Conservation, by Fred W. Herbert (Walck), is a book for anyone with a yen to pursue a career in this important field. It describes succinctly the work of soil scientists, soil conservationists, agronomists, range conservationists, conservation foresters, conservation biologists, conservation engineers, and technicians. Qualifications for such work are outlined, and government salary scales are listed. Several important career fields are not mentioned—for example, urban forestry, water resourc



conservation, airshed pollution control. However, the book should be of extreme value to a high school senior or college undergraduate who believes he wants a future in conservation.

The final book in this year's package, Naomi Talley's *To Save the Soil* (Dial), is a rehash of often-published information. The first half of the text, on early soil erosion problems and pioneer conservationists, apparently was taken from a Department of Agriculture publication written by Angus McDonald. The later part of the text skims over soil conservation practices and erosion problems in different portions of the country, but never seems to deal effectively with the subjects. This book does not seem a very strong competitor in an area already well covered.

JACK McCORMICK

Earth Sciences

THE subjects of popular scientific books follow closely the current "status" fields of science. Nowhere is this more evident than in the distribution of the sixteen books offered for review. Eight of these are in the general field of water and atmospheric science and reflect the growth of interest in all phases of water as they relate to man. With greater or lesser success such topics as irrigation, water control, pollution, and distribution are thoroughly dissected from all possible views. Of the remaining eight books, two discuss the Antarctic research program, three are concerned with earth history and evolution, and the remaining three are strictly adventure stories and cannot be construed as having scientific merit.

As could be expected, the "Life Science Library" has published a slick, beautifully illustrated, and comprehensive volume entitled *Water* (Time-Life Books), and has, as usual, selected a recognized authority, Luna B. Leopold, Chief Hydrologist of the U. S. Geological Survey, as the senior author (with Kenneth S. Davis and the Editors of *Life*).

A fine essay on the chemical and physical peculiarities and properties of water is presented in a series of photographs and excellently rendered color illustrations. An all-too-brief account of water distribution in relation to the earth as a whole follows. The chapter on ground water is about the best in the book.

For its purpose, the "Life Science Library" does well, but my feeling has always been that more textual material should be used—figure captions are one thing, but a clear, logical, and full discussion can rarely be bettered.

Water Fit to Use, by Carl W. Carlson and Bernice W. Carlson (John Day), is a thorough treatment of the misuse of water and what can be, and is being,

done about it. The principal objective is to make us aware—almost too aware—of pollution: its causes, effects, and possible solutions. There are the usual slips one expects in a generalized book for young people. For example, the authors claim that gases, minerals, and *bacteria* are dissolved in water! In general, the writing is a trifle simplified and stilted for the 10- to 14-year-old age group for which the publisher has recommended it. The photographs and illustrative material are excellent.

A rather comprehensive book on the origin, distribution, nature, and study of fresh waters is *Secrets of Inland Waters*, by Boris Arnov, Jr. (Little, Brown). It outlines for the uninitiated the general area and research of the limnologist. It is written in a clear, straightforward style, and the author never talks down to his readers. While the facts generally seem solid enough, there are a few slips. One has the feeling that the book was written as a textbook, clinically devoid of personal contamination; the result comes out dull.

Water Since the World Began, by Sigmund A. Lavine and Mart Casey (Dodd, Mead), covers about the same material as the other books of this set reviewed.

The book's general approach is the historical development of a particular subject (for example, a fine review of the scientific study of water, going back to the Greeks) and, thus, will certainly pique the interest of most students. However, I cannot give the book a high rating on factual content. Some statements are simply untrue, others are misleading. For example, the authors say that, "no living thing . . . can live more than a few minutes without oxygen." But there are exceptions—for instance, the anaerobic bacteria. There is the implication that fossils are the result of animals that died when lakes, formed from glacial melt water, dried up—this is certainly an irresponsible, misleading idea.

Donald E. Carr's *Death of the Sweet Waters* (Norton) uses a shock technique, attempting perhaps to shake people out of their lethargy and into action over the critical problems of water. The book is a thorough look into all stages of these problems, from shortages to pollution. His development of the subject is sound, beginning with ancient peoples' use and misuse of water. He obviously is so wrought up over our ineptitude in solving problems that he loses some objectivity and indulges in a few too many diatribes on political chicanery. I must stress a point that causes me to place this book on the not recommended list for young people. He is quite incontinent in his language, both in his too-frank jibes at his foes and in raw wording. As an example, he states that New England "would rather decay in its own puke than spend money."

Of all the adventure books reviewed this year, my favorite is *Rivers I Have Known*, by Willard Price (John Day). Mr. Price has given us his rich travel adventures on twelve rivers, including tales of the Grand Canal in China and canoeing on the Congo. Yet his ability in suspense writing makes a trip on the Hudson just as adventuresome. For those who want to escape, this is the book.

Captive Rivers, by Doris Faber (Putnam), is greatly biased in favor of dam building and tends to lack objectivity. Mrs. Faber says that the Big Muddy "had destroyed rich bottom land and kept agriculture from prospering as it should," and what the Missouri River needed was a plan to construct a series of dams. What is not mentioned is that overgrazing of cattle and lack of contour plowing were the primary factors in soil being stripped off farms, and that the mud during floods actually helped enrich the soil, as the Nile deposits do.

The chapter entitled "The Energy Race" is an interesting essay on how Russia is ahead of the United States in dam building (which of course is true), but why this should be used as a reason for us to build more dams is mystifying. I cannot recommend the book very highly because there is no balancing discussion of why dams should *not* be built.

On the positive side, the book is full of statistics and does manage to impress the reader with the many benefits to man of dams. On the whole this is definitely a book for the younger reader.

In sharp contrast to the Faber book is Elizabeth S. Helfman's *Rivers and Watersheds in America's Future* (McKay). Here is a fine review of the past lore, present misuse, and future outlook of rivers. Emphasis is on the control of rivers, primarily by dams, and the effects —both good and bad—of such control. The U. S. Army Corps of Engineers is roundly and deservedly criticized for its Prussian attitude toward building dams —the public be damned. The author employs the case history method of writing, using the Mississippi, Tennessee, and Colorado rivers as examples of good and bad management of water use. The infamous Kinzua Dam incident, involving the destruction of the Seneca Indian Reservation along the Allegheny River in New York (another masterpiece of indifference—courtesy, the Corps of Engineers) is thoroughly aired.

Thoughtful questions are posed regarding water control and management. This is an interesting book on a subject that doesn't ordinarily lend itself to exciting reading.

Weather Made Clear, by David C. Holmes, U.S.N. (Sterling), is a fine survey, with excellent documentation, of the fields of meteorology and climatology. The outstanding feature of the book is that the author discusses the physics and

chemistry of the air in relation to the spinning earth and gives a fine account of the origin of the atmosphere and life. The book ends with the effects of weather on the great battles of history and the effects of man on the weather. The illustrations are carefully selected and the writing is smooth and suspenseful. Highly recommended.

Two books deal with that enigmatic frozen wasteland the Antarctic, accurately and excitingly describing the life of U. S. scientists in that icy desert. It is most curious that both books parallel each other so closely in format, illustrations, and material covered. Many of the fine photographs are the same, and one almost has the feeling that they were written and edited by the same people. In my opinion the briefer and better of the two is Allyn Baum's *Antarctica: The Worst Place in the World* (Macmillan). There is much suspenseful writing, along with a nice balance of factual material covering the daily life, goals, accomplishments, and history of the Antarctic research programs. It is one of the most convincing and clearest pictures of what life is like there that I have yet read, and the illustrations blend well with the text. *This is Antarctica*, by Joseph M. Dukert (Coward-McCann), is essentially a duplicate of Baum's work in illustrations and material. It also is a well-rounded factual account covering life, history, and the future of exploration in this area.

Mountain Conquest, by Eric Shipton (American Heritage), is a knowledgeable book by a famous Himalayan climber who gives an excellent history of mountain climbing, starting with Michel Paccard's assault on Mont Blanc and concluding with the history of the Mount Everest and K2 triumphs. The book is lavishly illustrated and sprinkled with magnificent color photographs. For those who yearn for strict adventure on the mountain, this will do well. To the more discerning youngster, the question of what possessed that long line of men to climb for the sake of conquering is still unanswered. The pity is that so little valid science work was ever achieved by these men.

The Lewis and Clark Trail, by Calvin Tomkins (Harper & Row), is a perfectly written little volume for the young reader. Superior and appropriate illustrations are carefully placed so that the reader can easily match a photograph with the text. Frequent quotes from the original Lewis and Clark journals enhance the skillful writing of Mr. Tomkins. The appendix consists of twenty-one maps of the expedition's route west, along with a guide to today's recreation areas and historical sites for the traveler. These are well executed. The book is a perfect guide for a family interested in re-creating the famous expedition, as well as for the armchair explorer.

Three books deal with biological aspects of earth history. In the years following 1959, the publication centennial of *On the Origin of Species,* we have seen a great wealth of books on Charles Darwin. It is refreshing, therefore, to find an excellent biography, *Alfred Wallace: Explorer-Naturalist,* by Joseph Cottler (Little, Brown), of the man who nearly scooped Charles Darwin on the modern theory of evolution. The book creates a great deal of suspense and interest by fictionalizing the conversations and reactions of Wallace, his friends, and his family. At the same time it gives a thorough picture of Wallace in his early years (the book ends with Wallace in his 30's, when he returned from Asia—he was to live some 50 years longer) and reconstructs the development of his ideas of species evolution. Although the book is most welcome and highly recommended, it would have been of great aid to have included a list of books for further reading, particularly on Wallace in his later years.

Trilobite, Dinosaur and Man, by Clifford D. Simak (St. Martin's), is a compressed book on historical geology. As with most books on the subject it begins with the origin of the solar system and earth. It then launches into how the atmosphere, oceans, and life began and proceeds to march through the fossil and rock record from the Precambrian to Recent, concluding with an interesting chapter on "Man: The Triumph of Intelligence." It is a factually accurate account, but with the exception of a few anecdotes about collecting or discovery, it is a rather plain, almost sterile job. The illustrations are generally good, but I would have preferred more pictures of fossils. It is difficult in so small a volume as this to give a balanced coverage of material—this is particularly evident in his treatment of the post-Paleozoic life. The author devotes his coverage almost completely to vertebrate diversification, and the great adaptive radiation phenomenon of the ammonites is not even mentioned. This book will not hold young readers at the edge of their chairs, but it does cover the subject well.

Carroll Lane Fenton's *Tales Told by Fossils* (Doubleday) is another of the polished, beautifully illustrated, and rather accurate books in the long series of popular writings by the Fentons. After the usual introduction, discussing what fossils are, their distribution and significance as time indicators and use in reconstructing ancient ecology, the author proceeds to concentrate on a selected group of fossils to show us how fossils and their characters can be used. Most of the book deals with vertebrate fossils and shows not only how their own features can indicate diet, habitat, and predators but also how the associated fossils and the rock that encloses them can greatly aid in giving a vivid picture of the extinct landscape and its inhabitants. A fine survey of the evolution of man completes the discussion, followed by a final chapter on museums in the United States that exhibit fossils and a suggested reading list. There are a few inaccuracies, but generally a recommended book.

ROGER L. BATTEN

Invertebrate Biology

SINCE the living world is full of wondrous things, there is always room for more good books that tell about them. Many of the volumes reviewed here will be an asset to any young naturalist's or biologist's library.

Triumphs of Biology (Doubleday) is ably written by Philip Goldstein, who presents difficult concepts with considerable clarity, but it is not for young readers, and even the high school student will find tough going in places. The volume is really a short history of genetics, dealing with the work of Mendel, the genetics of color blindness and sickle-cell anemia, and the modern work in bacterial genetics, viral genetics, and the chemical nature of the gene.

A book designed "to supplement classroom and laboratory study in biology" is *Basic Biology—Volume I, The Animal Kingdom,* by Jean Vallin (Sterling). It presents the external and internal anatomy, mode of life, and mode of reproduction of representatives of ten of the major animal phyla. That the animals described are only *representatives* is not made clear, so what is said about a particular animal may lead readers to infer that this is so for the rest, or for a great part, of the phylum, class, or order. Aside from this propensity to generalize, the book is marred by uninspired writing (or, perhaps, a poor translation from the French), factual errors, and poor copy editing. The one saving grace is that the book is lavishly illustrated with good color photographs and quite adequate diagrams of the external and internal anatomy of the animals represented.

Richard Harbeck's little volume on *Exploring Science in Your Home Laboratory* (Four Winds) is an excellent guide to planning and equipping a home laboratory. The purpose of the book is to help satisfy one's curiosity "in a way that scientists have been doing for centuries: *by experiment.*" The author provides ingenious suggestions (accompanied by appropriate illustrations) for making serviceable laboratory equipment—from alcohol lamps to wash bottles—out of castoff materials found in the home or from materials purchased at little expense. The volume is well indexed, and there is useful information on common chemical compounds, the chem-

ical elements, and units of measurement.

Mr. Harbeck gives tips on how to go about getting answers, by experiment, to problems suitable for study in a home laboratory in the fields of biology, chemistry, physics, earth science, and space science. Some of these tips, however, are not too helpful unless the reader has more than a nodding acquaintance with a chosen field. Here is where the author does not complete the task of launching a young investigator. He does not give references or suggestions on how one goes about finding relevant material in a library. But this may be a minor criticism. Mr. Harbeck does show the way to find the why and how of things.

M. D. Anderson's *Through the Microscope* (Natural History Press), and *The Microscope*, by C. William Harrison (Messner), are both concerned with the history of microscopy and some of its applications today. Both deal adequately with the optics of simple and compound microscopes. The Anderson book, which is fully illustrated with photomicrographs and drawings, is the more attractive and interesting of the two. There is an outstanding discussion of the works of the early microscopists. It is fascinating to read a direct quote from Leeuwenhoek's description of *Vorticella* and to see a reproduction of his drawing of this organism. *Through the Microscope* introduces the high school reader to many fields of biology, including botany, zoology, microbiology, genetics, hematology, and embryology. It makes the reader want to go into the laboratory and see for himself some of the fascinating things described and pictured.

The Microscope, which is written in a folksy manner, places more emphasis on the optical advances made by some of the early pioneers and has a number of interesting photographs of early microscopes and a variety of modern instruments. However, it is full of speculation on what Leeuwenhoek might have said on various occasions, what the neighbors thought of him, and other trivia.

Collecting and Photographing Your Microzoo, by Roy Pinney (World), is a slender volume designed to teach the budding microscopist to prepare cultures, make slides, and photograph what he sees through the microscope. The text is too brief to be of real assistance and contains many errors; the most useful feature is the bibliography.

I found no appeal in the slim volume *Bacteria and Viruses: Friends or Foes?*, by William and Nellie Slaton (Prentice-Hall). By its format, I assume the book to be intended for young readers, yet the use of many fairly technical terms and concepts, without necessary explanations, seems to belie this. The writing is often not clear and in some places, downright murky. Some of the illustrations are not accurately labeled, and most do not enlighten the text. This book has more than its quota of errors.

Some absorbing tales of the lives of worms, spiders, bats, octopuses, snakes, toads, and cockroaches are told in Robert Froman's *Spiders, Snakes, and Other Outcasts* (Lippincott). The author writes about these animals with sympathy, but not sentimentally, the tenor of his approach being that "to look down our noses at . . . any creature is to look down our noses at the same evolutionary process that produced ourselves." The book is sparsely illustrated, but there is an index and a bibliography listing a number of references on these "outcasts."

How insects are adapted for their myriad ways of life is ably and interestingly portrayed by Ross E. Hutchins in his *Insects* (Prentice-Hall). Geared for high school and adult readers, this book presents a classification of the insects, a general treatment of the world of insects, a survey of their behavior and senses, and a detailed discussion of their varied ecological niches: that is, how insects make their living. Excellent photographs amplify the text. My greatest disappointment is the author's reliance upon the dubious concept of instinct, or "inherited knowledge," to explain almost all of insect behavior. Instinct, unless precisely defined, is no explanation. We, for the most part, just do not know why an insect behaves as it does, except that this behavior is the result of the interaction of many variables. *Insects* is recommended if one does not expect to learn the why of insect behavior.

Insects from Close Up (Crowell) is a limited survey of the more common orders of insects, written by Eleanor Ivanye Fanning and enlightened by many fine photographs by Harry F. Brevoort. This is a good general introduction, and it includes an abbreviated section on insect relatives—spiders, crustaceans, millipedes, and centipedes. There is also a brief note on the techniques of photographing insects.

A book that reads something like a newspaper account of the wonders of science is *Fireflies in Nature and the Laboratory*, by Lynn and Gray Poole (Crowell). This volume is less about fireflies than about bioluminescence. It is rambling, poorly written, has a number of errors, and would probably be over the heads of most young readers.

Just the opposite can be said for Alice L. Hopf's *Monarch Butterflies* (Crowell), a lucid and lively account of the life of the monarch and its phenomenal migrations. Miss Hopf writes from many years of personal involvement in raising monarchs and tagging them so that their migrations might be followed. She tells how to collect monarch eggs, larvae, and adults, how to house and raise them, how to tag and photograph them. This book should recruit many readers in the at-

tempt to solve the mysteries of monarch migration and other aspects of its life.

One of the best books concerning ant life I have read is *All About Ants*, by Peggy Pickering Larson and Mervin W. Larson (World). This is a well-written text on the evolutionary history of the ants—their adaptive radiation into a variety of habitats and their adaptations for specific ecological niches. The complexity of ant social organization, including the determination of castes, is skillfully presented. In this book, too, there is reliance on the concept of instinct to explain ant behavior. On the whole, however, the authors are to be congratulated for this fine volume on ants and their ways.

KENNETH K. COOPER

Vertebrate and Marine Biology

MANY animal stories dealing mainly with the lives of mammals and birds have an important new concern: the conservation of our wildlife on national and international levels. Because of this emphasis, several books that might otherwise be considered commonplace are recommended and, in fact, urged upon young readers. Conservation of our resources cannot wait to be carried out by the generations of the future. If the problems are not faced now, there will be nothing to conserve later.

Two birds that should be treasured are the subjects of *The Golden Eagle*, by Robert Murphy (Dutton), and *The Last Eagle* (the bald eagle), by Dan Mannix (McGraw-Hill). Each book personifies an individual eagle and traces its life history, weaving biological details into daily patterns of activity. The authors describe flying, hunting, nesting sites, courtship, parental care, and predation by man. The writing in *The Golden Eagle* is sheer poetry, while *The Last Eagle* is competently and clearly written. Since I am negatively inclined toward books that tend to make animals into humans, I tussled with my conscience about the personification of eagles in these books. I decided that the end result is worthy of the novel approach if the reader understands that literary liberty has been employed.

Raccoons & Eagles, by Polly Redford (Dutton), is also conservation oriented. Mrs. Redford has researched historical records, literature, and material on natural history, and has written this captivating book on the life history of Floridian raccoons and the bald eagle. She presents techniques for raccoon catching and ways to keep them as pets, in addition to methods for eagle watching. Her style is smooth, and her accounts of personal experiences with these animals are both whimsical and serious, without resorting to coy anthropomorphisms. Mrs. Redford pleads for conservation of the bald eagle (the versatile raccoon is becoming a suburbanite), and she points out that it will be a tragedy if our national bird becomes extinct. The book has an excellent bibliography and a thorough index.

Another bird of prey is surveyed in *The World of the Great Horned Owl*, by G. Ronald Austing and John B. Holt, Jr. (Lippincott). The authors capture, through unique and striking photographs, owls on the hunt, flying, catching prey, and rearing their young. In addition to biological information, there is a considerable section on personal experiences with owl rearing and owl keeping, and excellent pointers on where to find the great horned owl and its nests. The book has a long and pertinent bibliography and an index.

Similarly framed around impressive photographs, *Cottontail*, by Leonard Lee Rue III (Crowell) shows rabbits in action and in various developmental phases, and their life story is traced

throughout the four seasons. It is lucidly written and has an index.

The Wildlife of Africa, by Jocelyn Arundel (Hastings House), concerns itself with the approaching extinction of a number of African animals, catapulted by the predation of man. The title is a bit misleading, for wildlife, per se, forms but a small part of the story, which is mainly about predation by slave traders, ivory hunters, and European settlers. One chapter lists the animals whose low population numbers place them on the brink of permanent disappearance; another covers the national parks of Africa and includes maps; and a third describes new ways of conservation and land utilization. The book's primary and most worthy contribution is that it makes a forceful plea for conservation. It has an index and glossary, and the writing is agreeable and easy to read.

Going north and west to the continent of North America, we find a number of books about mammals. *Our Wild Animals*, by John Bailey, with photographs by Leonard Lee Rue III (Nelson), is not specifically an argument for preservation of our national wildlife, but is oriented toward its appreciation. The selection of more than forty mammals was probably dictated by the collection of high-quality photographs. The book starts with the tiny shrew and ends with the large buffalo. In between it describes many well-known animals, such as the chipmunk, the squirrel, the woodchuck, and the raccoon. For identification of each there is a photograph, a diagram of the mammal's foot, and a silhouette of its footprint. The text surveys habits and habitats, and includes a few scientific researches carried out on some of the animals. By and large, the biological descriptions ring, commendably, of Ernest Walker's books on mammals. If the authors had sought out the more recent experimental and observational studies of mammals, the book could have left the realm of "better-than-ordinary." It has a geographical distribution table, but no index.

Wild Captives, by Donald G. Dodds (St. Martin's), is a book that disturbed me. It is more a story of death than of life. Mr. Dodds decries the terrible and needless killing of so much wildlife by means of the gun and the trap, but the book left me with a sense of hopelessness, rather than inspiration to save these animals. For example, the epilogue, which should have proposed concrete ways to conserve, instead told the story of a moose being quartered. Mr. Dodds is obviously fond of these animals and writes well, with considerable feeling and an occasional twinge of bitterness. The portraits of the subjects by Ronald Andrews are exquisite. There is no index.

Two books are specifically about bears: *American Bears*, by B. F. Beebe and James Ralph Johnson (McKay), and *No Room for Bears*, by Frank Dufresne (Holt, Rinehart and Winston). The first is a well-written, straightforward account of the life of the black, grizzly, and polar bears. It covers behavior, hibernation, and general biology, and includes stories of bear attacks. The bibliography and index are comprehensive, and there is one illustration. The second book laments the future disappearance of bears unless some steps are taken toward conservation of areas where they can live. It is primarily an adventure story with accounts of the habits of grizzly and sundry other bears. The book is fast moving and entertaining, and scenic Alaska comes very much to life. The story begins as a plea to preserve living space for bears on Admiralty Island, but it develops into a series of spellbinding anecdotes about close calls with bears—in which the bear lost. There is no index.

Wild Dogs, by C. B. Colby (Duell, Sloan & Pearce), is a dull book. The author surveys some members of the family Canidae, such as the fox, coyote,

jackal, and timber wolf, and persists in referring to them in humanoid terms. Each "dog" is illustrated with a mediocre photograph and a track silhouette.

South American animals have been touched upon in two adventure stories, *Animals of the High Andes*, by Alida Malkus (Abelard-Schuman), and *Animals of the Valley of the Amazon*, by Cecile Hulse Matschat (Abelard-Schuman). It is refreshing to find stories about South American animals entering the realm of juvenile books. Each book is essentially a travelogue and traces a course, with boys and native guides, through the appropriate geographical region. It is during these travels that a variety of animals, often unusual and strange to us, are seen and discussed, with a few biological facts about each presented to the reader. The books should at least serve to awaken interest in South America.

Several books deal with broad biological subjects. *Forgotten by Time: A Book of Living Fossils*, by Robert Silverberg (Crowell), is about animals and plants that have come through a long evolutionary history with relatively minor structural changes. The tanklike horseshoe crab, the recently famous coelacanth, the little-known tuatara, the marsupials, tree ferns, and flightless birds are examples. Mr. Silverberg, however, does not quite appreciate the meaning of time in terms of evolution and survival. How can he casually say that dinosaurs were unsuccessful? Certainly 100,000,000 years of survival should be considered success. The subject matter is sufficiently unique to warrant a reading, and the writing style is easy to follow. The black-and-white drawings are fair, and the book has a good index plus a full list for further reading.

The subject of *Animals on the Move*, by Ann and Myron Sutton (McNally), is an interesting one, but the animals are mainly birds, and the story is about their migrations. Migrations vary, and they are carried out under different stimuli for different groups. The authors perhaps should have investigated more of the currently available studies. The book is amply illustrated by Paula Hutchison with examples of migratory flyways and species types. The index is good, but the reading list is unimaginative.

James Poling presents a well-written account of camouflage and mimicry in the book *Animals in Disguise* (Norton). The author distinguishes between various kinds of disguises: protective coloration, body markings, shadings, concealment through behavior, misdirecting markings (such as eyelike shapes on the tail), and mimicry—when harmless animals resemble those that are malodorous, non-palatable, or dangerous. The black-and-white photographs are striking, but one wishes for more pictures in

color. The book has a suggested reading list and a comprehensive index.

Written by the behaviorist J. D. Carthy, *Animals and Their Ways* (Natural History Press) is a glimpse into the highly complex subject of animal behavior. The material is fresh, and the studies presented are those of modern behavioral researches. Dr. Carthy surveys sensory receptors and stimuli, social organization, territoriality, courtship, parental care, rhythms in activity, learning, genetics, and the adaptive nature of behavior. One of the book's difficulties is that too much is covered and too many facts are packed into a small space with the result that some of the concepts are not clearly expounded. For example, forty-one lines on perception will leave it quite unperceived—better to have left it out. Also, because of the density of material, modifiers were omitted; many statements are all-inclusive, which frequently makes them not quite true. For example, the statement that human societies have more in common with societies of ants and bees is most provocative, and needs an explanation of the viewpoint. I found several errors referring to fish schooling, a special interest of mine. The book is profusely illustrated with photographs, line drawings, diagrams, and etchings, but the labeling in some is modest. While the book will fascinate many readers and open new areas of thought about behavior, it reads as if it were hastily written, and the index is poor.

In the same field is a breezily written book, *How Animals Communicate*, by Bil Gilbert (Pantheon). Except for bee dances—which may function through vibrations—the author deals mainly in sound production, primarily in birds, dogs, dolphins, and chimpanzees. In his intense desire to separate animal language from human language, he made the point unnecessarily complicated. Perhaps he should have avoided the term animal language and used only the term animal communication. He does mention that animals communicate through signs, contacts, odors, and vibrations, but proceeds largely to ignore these forms of communication (except in birds) and to concentrate on those he apparently would like to push closer to the realm of human conversation. If his philosophy had been more objective, the book would have been recommended as a stimulating introduction into systems of animal communication. The writing has an anecdotal quality, and the personal experiences with dogs are good stories that include useful information about training. There is no index, and the reading list is fair.

The Armor Within Us, by Joseph Jamachson (McNally), is the story of bone, its growth, chemistry, and structure, seen mainly through the studies of historical and modern researches. It is

of pertinence to all biology students and to those who wish to understand bone as a living tissue with a complex metabolic system. The book could have been improved with more and better illustrations, specifically in relation to discussions of metabolism and structure, and the diagrams should have had more adequate labeling. The photographs are poorly reproduced. The writing is a little heavy but clear, and the author has included an excellent glossary of technical terms and a good index.

If books about people and their pets are kept within their limitations, as personal narratives and anecdotes, they are splendid and serve to enhance curiosity about animals. My objections come when the author's emotions masquerade as scientific research. In *Samba and the Monkey Mind* (Norton), Leonard Williams describes, in great detail, his life with woolly monkeys kept as pets in his English household. If he had limited his story to the woolly monkeys, all would have been well. But instead he abstracted his experiences into the field of monkey and ape behavior, became involved in the philosophy of studying behavior, and immediately ran into trouble. A quote from his book sums up his reaction: "How can we . . . avoid the tendency to humanize . . . ? If we renounce the human standard of measurement, what standard is left by which to measure anything?" However, humanizing and measuring are not synonyms, and more can be learned if we think of animals as having their own levels of organization and behavior.

Another story of personal experiences with animals is *Such Agreeable Friends*, by Bernhard Grzimek (Hill and Wang). After reading it I felt that I haven't lived because I have not had a chimpanzee in my house—toppling lamps, ripping curtains, and using bedding as a bathroom. Are such intimacies necessary in order to prove that you have admiration and interest in animals? In addition to chimpanzees, Dr. Grzimek discusses other apes, horses, elephants, dogs, and wolves. Of course, many of these were housed in zoos. The book has an index and contains photographs of many of the pets.

A book of personal anecdotes that I found unpretentious and charming is *An African Zoo in the Family*, by Joan Winifred Taylor (Emerson). Mrs. Taylor accepted animals as animals, admired them, and urged their conservation, but she felt no need to make them human in order to make them valuable. The story relates her experiences as a gamekeeper's wife in Rhodesia and her distress as she witnessed the destruction, under government edict, of many local animals.

There are five books about the sea. *The Ocean World*, by Vladimir and Nada Kovalik (Holiday House), is one of those rare books in which the serious student can find out what it means to become an oceanographer and the kinds of studies that are made under that designation. It is encyclopedic in its survey of the physical oceanographer, the biological oceanographer, the chemist, etc. There are sections on history, on modern technology, and on some of the properties of the sea. The selected photographs are unusual and come, by and large, directly from research institutions. At the end is a list of schools where one can study oceanography, an excellent reading list, and a splendid index—a worthwhile reference source for the embryonic oceanographer. All in all, a highly recommended book.

Something Rich and Strange, by Robert E. Schroeder (Harper & Row), is a romantic account of the author's experiences, diving day and night, around the Virgin Islands and the Florida Keys. His love of the coral reefs and of Scuba diving is apparent throughout the pages. Unfortunately he succumbed to th[e] temptation of personalizing his animals and he tells the reader that a conch ha[s] alert and intelligent eyes and that earl[y] in June a redfin parrot fish begins to b[e] bothered by unfulfillment. Statement[s] such as these are unforgivable comin[g] from a biologist. The book is easy t[o] read, and will hold one's attention. Th[e] photographs are in color, and there i[s] an elaborate index.

The World of Coral, by Robert Silve[r]berg (Duell, Sloan & Pearce), is also [a] story about coral reefs, derived from th[e] author's experiences among the reef[s]. The best part of the story tells how cor[al] reefs develop and how they interact dy[namically] with the sea—so often on[e] thinks of corals as being static and with[out] life. Small and large reefs and the[ir] inhabitants are surveyed around th[e] world, and the scientific studies bein[g] carried out on reef building and reef li[fe] are described. The writing is a bit p[e]dantic but easy to follow. Mr. Silverbe[rg] tends to apply generalizations to sp[e]cifics, such as implying that fish livin[g] in reefs can swim 50 miles an hour [or] that the danger of shark attacks [is] greater in New Jersey than the Baham[as] (on what authority?). The photograph[ic] reproductions are very poor, and the[re] is not a color picture in sight. Color do[es] make up much of the beauty of a ree[f].

Jacques-Yves Cousteau's *World With[out] Sun*, edited by James Dugan (Ha[r]per & Row), is the still version of t[he] film of the same name. The writing [is] lovely, the color photographs are cli[ps] from the motion picture, and the tale [it] has to tell is of man's future under t[he] sea. This is a most attractive book.

The Wonderful Dolphins (Hawthor[n]) is a bad book. It is bad not because [it] lacks the ever-charming photographs [of] dolphins and not because it fails to [de]scribe many of the species, their dist-

bution. and some of their biology; it does these things amply well. It is bad because the author, John Bailey, in his approach to these delightful beasts, wanted them to be clever. witty. and conversational. He even asks. "Does the dolphin have a racial memory and does it vaguely remember when it was a creodont? It almost seems to." His chapter. in fact. on how a creodont changed into a dolphin belongs in a book of fairy tales. If only dolphins could talk to us, perhaps they could tell us how silly we are to try to make them into humans.

A World of Snakes, by Thomas Helm (Dodd, Mead), is primarily based on the personal experiences of the author and others. His acknowledgement list is a compilation of virtually all the snake experts. but his bibliography omits one of the best books on snakes, that of Clifford Pope. The slant of the book is mainly toward snake bite. including clinical details, and there is little on the biology of snakes. The emphasis is on the big and dangerous snakes and on the men who handle them. Scientific names are given along with popular ones. and the photographs are good.

Alexander Wilson: Wanderer in the Wilderness, by Robert Plate (McKay), is a biography of this now famous ornithologist whose life during the early nineteenth century was one of despair and difficulty. but who. despite this. went on to draw and to observe the birds he loved. The driving passion of the man is well presented in this thoughtful and sensitive account of his life.

EVELYN SHAW

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39—AMNH after Schneider
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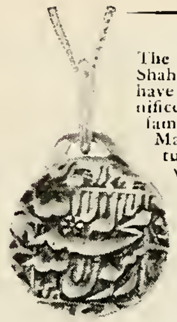

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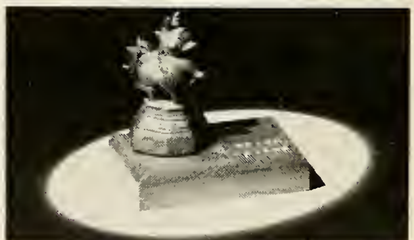

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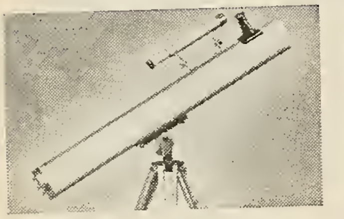

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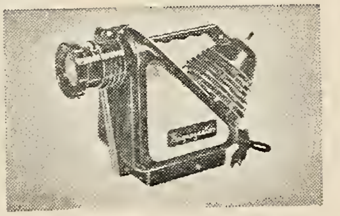

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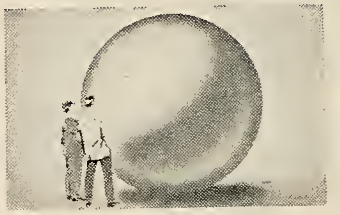

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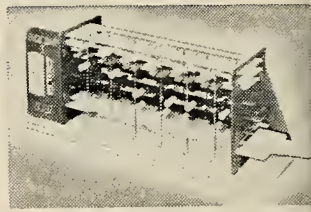

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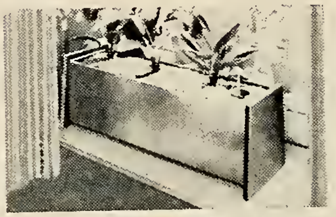

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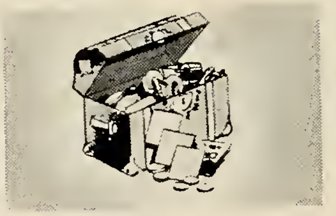

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Suggested Additional Reading

THE EVOLUTION OF CRICKET CHIRPS

Insect-Musicians and Cricket-Champions of China. B. Laufer. Field Museum of Natural History. Dept. of Anthropology Leaflet No. 22. 1927.

Evolutionary Change in Cricket Acoustical Communications. R. D. Alexander. *Evolution*, Vol. 16. pages 443-467, 1962.

Insect Sounds. P. T. Haskell. Quadrangle Books. Chicago, 1961.

The Song of Insects. P. T. Pierce. Quadrangle Books. Chicago. 1948.

WATER AND THE EVERGLADES

Across the Everglades: A Canoe Journey of Exploration. H. L. Willoughby. J. B. Lippincott Co., Philadelphia, 1898.

The Everglades: River of Grass. M. S. Douglas. Rinehart & Co., New York, 1947.

Water Resources of Southeastern Florida. G. G. Parker *et al.* U.S. Geological Survey Water-Supply Paper 1255, 1955.

SOME SYMBIONTS OF THE SEA

Symbiodinium gen. nov. and Symbiodinium microadriaticum sp. nov., a Zooxanthella: Taxonomy, Life Cycle and Morphology. H. D. Freudenthal. *The Journal of Protozoology*, Vol. 9, No. 1, pages 45-52, 1962.

Problems of Growth and Calcium Deposition in Reef Corals. T. F. Goreau. *Endeavour*, Vol. 20, No. 77, pages 32-39. 1961.

Axenic Zooxanthellae from Various Invertebrate Hosts. J. J. A. McLaughlin and P. A. Zahl. *Annals of the New York Academy of Sciences*, Vol. 77, No. 2, pages 55-72. 1959.

Scientific Reports. Great Barrier Reef Expedition 1928-29. C. M. Yonge and A. G. Nicholls. British Museum (Natural History), Vol. 1. 1930-31.

ALLIGATOR

The Alligator's Life History. E. A. McIlhenny. Christopher Publishing House, Boston. 1935.

THE ENDURING INDIAN

American Indians. W. T. Hagan. University of Chicago Press, Chicago, 1961.

Indians and Other Americans. H. E. Fey and D. McNickle. Harpers, New York, 1959.

The Indian Today. *Midcontinent American Studies Journal*, Vol. 6, No. 2, Fall, 1965. University of Kansas, Lawrence.

Ev Sherrick was a "test pilot" at twelve.

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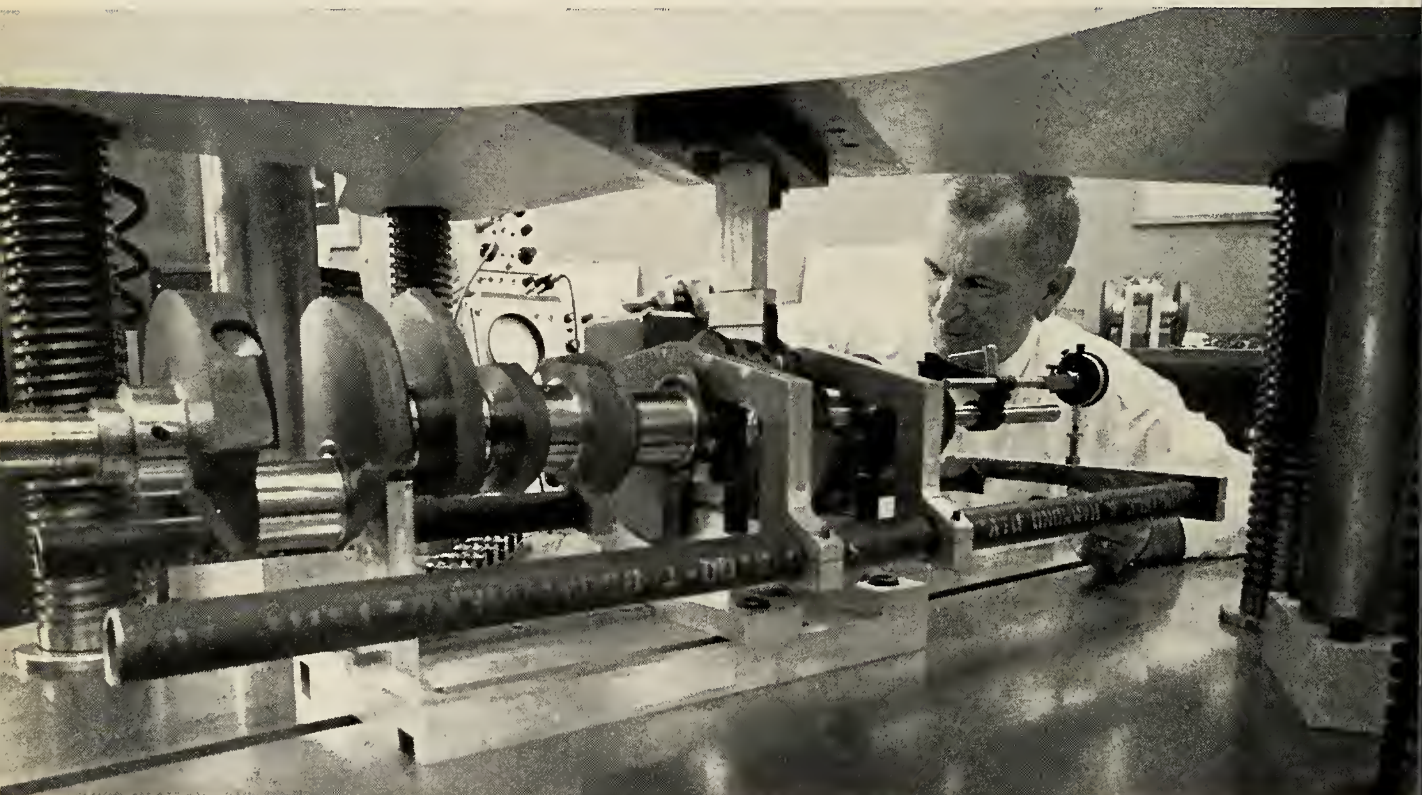

Seven years before the "Spirit of St. Louis" landed near Paris, young Ev Sherrick was launching his first plane—a home-made model, powered by an outsized rubber band. His goal: to design the plane to fly as long as the power would last and to ensure a safe landing.

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Ev started his GM career in 1925 with Cadillac Division as a draftsman, with emphasis on camshaft and crankshaft design. During World War II, he specialized on structural analysis for aircraft engines with GM's Allison Division. Today, he heads up a group of engineering specialists who test for stress . . . study structural strength of durable materials day in and day out. Their tests are exhaustive, intensive and continuous . . . solely designed to put safer, stronger more reliable cars on the road.

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Natural History

December 1966 • 70¢

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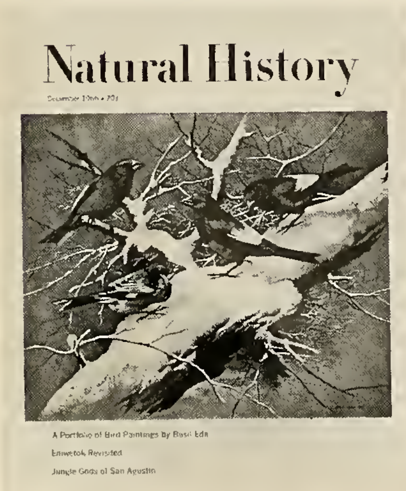

Natural History

Incorporating Nature Magazine

THE JOURNAL OF THE AMERICAN MUSEUM OF NATURAL HISTORY

Vol. LXXV　　DECEMBER 1966　　No. 10

ARTICLES

DEPARTMENTS

COVER: A Lee Boltin photograph of Basil Ede's painting of a winter group of Eastern Evening Grosbeaks, *Hesperiphona vespertina*, is shown on this month's cover. A review with full-color reproductions of nine other Basil Ede paintings begins on page 32. In the winter in the eastern part of the country, Evening Grosbeaks—which are colonial feeders—may travel in small groups, as portrayed in the painting, or in large ones containing a hundred birds. The group here is composed of a female and three males. The female, although generally duller, has more white on wings and tail. All grosbeaks have large, cone-shaped bills.

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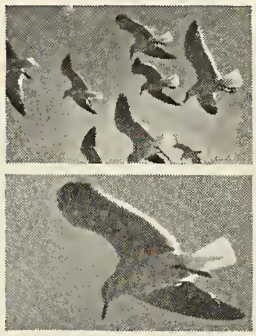

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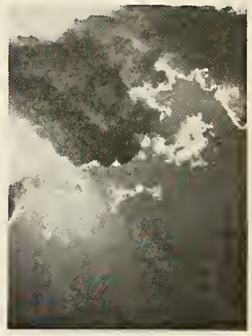

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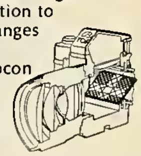

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Michael Berrill

ABOUT

Gerardo Reichel-Dolmatoff

When the first of several nuclear devices was detonated on Eniwetok Atoll in the southern Pacific in 1948, Michael Berrill had just celebrated his fourth birthday. Recently this young biologist spent three weeks exploring the islands and reefs of Eniwetok in conjunction with academic work at the University of Hawaii. His visit resulted in "Stillness on Eniwetok." Mr. Berrill is currently working on his Ph.D. in biology at Princeton, studying the comparative behavior of several species of marine mysid shrimp. He received a B.S. from McGill, an M.S. from the University of Hawaii, and spent an additional year in Hawaii as a Woodrow Wilson Fellow. This past summer Mr. Berrill worked in Jamaica at the Port Royal Marine Laboratory.

Marc Roth wrote "The Allure of the Female Mosquito" along with his father, Louis M. Roth, who heads the department of entomology at the U.S. Army Natick Laboratories, Natick, Mass., and Thomas Eisner, Professor of Biology at Cornell. A Cornell graduate, Marc Roth had formerly been employed by the Canadian government's Insect Pathology Research Institute, and now works for the U.S. National Museum in Washington, D.C. Dr. Louis Roth, who holds a doctorate from Ohio State, is au-

Marc Roth

Thomas Eisner

Louis Roth

THE AUTHORS

Basil Ede

Harold Gilliam

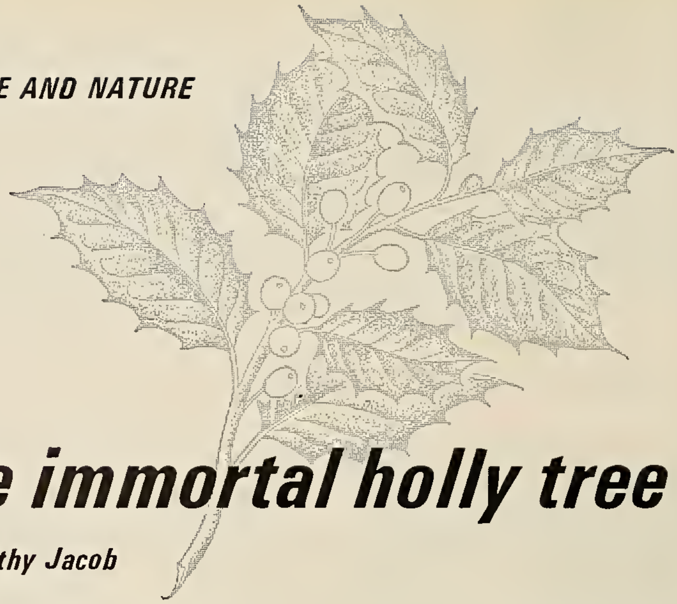
thor of numerous papers in entomology. One of his main research interests centers on the biology of cockroaches. In addition to teaching, Professor Eisner conducts research on the physiology, biochemistry, and behavior of insects. He received a Ph.D. from Harvard and has written over seventy articles, several of which have appeared in NATURAL HISTORY. His article on defensive secretions of beetles appeared in our February issue.

BASIL EDE, artist of the bird paintings reproduced in this issue, was born in Surrey, England. He studied art and architecture at St. John's School and at Kingston School. In 1956 Mr. Ede sold his first paintings and two years later gave his first London exhibition. He gave several more shows in the next few years and enjoyed wide critical acclaim. In 1964 Mr. Ede's first American exhibit was held at the Smithsonian Institution in Washington. The *Atlantic Naturalist* said, "The paintings are distinguished by a brilliant mastery of texture and color." Thirty-six of his paintings were reproduced in a book, *Birds of Town and Village*, published in 1965. Mr. Ede's style and technique were influenced by several trips to Japan.

GERARDO REICHEL-DOLMATOFF, author of "Jungle Gods of San Agustín," was born in Austria and educated in Vienna, Munich, and Paris. He has been a resident of Colombia since 1939, when he helped organize anthropological research in that country. He has been a Government Anthropologist for almost twenty years and is now Chairman of the Department of Anthropology, University of the Andes, Bogotá. Dr. Reichel-Dolmatoff has written several books on Colombian Indian cultures and was elected an Honorary Fellow of the Royal Anthropological Institute. He has received an honorary doctorate, and was awarded high government distinctions for services to his country.

HAROLD GILLIAM is the author of "Tree of Light," an excerpt from his forthcoming book, *The Natural World of San Francisco*. A native Californian, Mr. Gilliam has written many books on San Francisco. He holds an M.A. from the University of California at Berkeley and has also studied writing under Wallace Stegner at Stanford. Mr. Gilliam has worked on the *San Francisco Chronicle* and the *San Francisco Examiner*, has taught at San Francisco State, and has been a member of the city's Art Commission. For some time, he served as a special consultant to Secretary of the Interior Stewart Udall.

FOLKLORE AND NATURE



The immortal holly tree

By Dorothy Jacob

It is possible that the holly was the first tree of which intelligent man took conscious cognizance, but we must go back before the dawn of history to look for the evidence. History as we know it only began when man devised a means of communicating and recording events by signs scratched on stones, which he much later elaborated into writing. Before that, all history is inherited memory, or folklore—composed of legend, belief, memory, and imagination stored up and passed down from generation to generation.

The belief that trees contained living souls and individualities was universal throughout the Old World. Man's earliest known form of recognizable worship (we must exclude the primitive instinct that made the sun his first god) was the worship of trees. Of these, three trees reigned supreme: the oak, the ash, and the holly. The one that seemed to affect man most strongly in his mental development was the holly; it was probably his earliest intimation of immortality. When many other trees apparently died, holly retained its green growth. Moreover, it annexed the sacred color of fire, which belonged to the sun, and reproduced itself by means of its scarlet seed.

Holly was believed to be so powerful in its magic that it came to be looked on as a protector, especially in England and Scandinavia and probably throughout Europe. Man, in time, made his dwelling in places where there was an abundance of holly. English place-names such as Holmesdale, Holmwood, or Holmfirth mean places where much holly grew. The old country names for holly were *holm* or *hulver* and were derived from the Old English holen. In recognition of its strength and vigor it was gradually given a new status and was designated as masculine. Later, the ivy, of newer lineage than the holly, was accepted as feminine.

As the centuries passed, this became a standard belief. We meet it again and again in ancient songs, legends, and writings. The carol:

Oh the holly and the ivy
When they are both full grown,
Of all the trees
  that are in the wood
The holly bears the crown.

is based on an older one first heard in the reign of King Henry VIII. The earliest known reference to holly in an English carol is in one of Henry VI's reign, which says:

Nay, ivy, nay.
It shall not be, I wys.
Let Holly have the master,
  as the manner is.
Holly stand in the Halle,
  fayre to behold;
Ivy stand without the door;
She is full a'cold.

The spiny type of holly is traditionally lucky for men, while the smooth-leaved variety without any prickles brings good fortune to women. Again, tradition has it that whichever type is brought into the house in greater quantity at Christmas determines whether the man or woman in the house will have the mastery throughout the year.

So strong was the conviction of the powers and attributes of the holly that until quite recent times—within the last 200 years—the austerities of Lent were begun with the ritual burning of male and female effigies: the "man" made from holly and known as the "holly boy," and the woman made of ivy and called the "ivy girl." Holly's association with paganism was so ingrained that for hundreds of years its use as a Christmas decoration for the churches was forbidden throughout Europe.

During the great December festival of the Roman Saturnalia at the winter solstice, which preceded our Christian Christmas, it was the custom for the

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Romans to express their good wishes to their friends by sending them branches of holly. In the rites and festivals of the winter solstice, holly played a most conspicuous part, especially in the northern countries. Its brilliant, sparkling leaves and gay berries made it the obvious choice for decoration. The winter solstice was the birth of the new sun—the turn of the year—a symbol of primitive man's early worship when he discovered the sun to be the source of his heat and light. The birthday of this universal god was in midwinter, when the sun began the renewal of his warmth. Later, this new sun evolved into the Persian god Mithra. His cult was immensely popular, and many of our Christmas rites and festivities have been borrowed from the Mithraic worship. In fact, Christianity ran so close to it, it was at times confused with Mithraism. The disciples of Zoroaster—the fire-worshipers—believed the sun never shadowed holly. Remnants of this sect still remain in Iran and India and are said to throw water impregnated with holly bark into the face of a newborn baby.

At a place called Butley, located in the county of Suffolk, England, there is a small wood, the remains of a vast forest, thousands of years old, that once almost covered the county. It is composed entirely of the three magic trees —the oak, the ash, and the holly. Although it antedated the Druids by many hundreds of years, there is no question that they annexed it for their rites and ceremonials, for they always established their "groves" where the magic trio was already growing. The trees in that wood are so dwarfed, twisted, and shrunken as to have lost all claim to arboreal reality. Their vigor and beauty have long since left them. No ray of sunshine can penetrate the thick mat woven from their interlaced and diseased boughs.

In this still living wreckage the dominant tree is the holly. So vigorous and tenacious is it that, even where age has destroyed the oaks and ashes, holly still sows its seeds and renews its life with fresh saplings that grow in the broken trunks of its weaker partners.

Crown of Thorns

As the centuries passed, tree worship, Roman orgies, druidical rites, and other celebrations faded, leaving only December's great Christian festival, which included parts of the earlier celebrations. Throughout this kaleidoscopic change in practices and beliefs, holly, the emblem of gaiety and goodwill, maintained its place. Eventually even the church acknowledged it, and with this sign of approval it gained the

name of the "holy tree" from the legend that holly, not hawthorn or bramble, was used for the crown of thorns. Also, it was now constantly planted in churchyards—particularly in England and Scandinavia—because of the belief that marauding witches and spirits frequently concocted spells there. This seemed to admit its pagan-designated power as a protector. For by now, the witch was in the ascendent, and protection against witchcraft was essential. Holly was anathema to witches. It was potent against any form of evil but most particularly in averting witchcraft. For this reason it became usual to plant a holly close to dwellings and stables, to protect the inhabitants. Even a witch who customarily made her home in a hawthorn or an elder could not be induced to live in a holly tree. There were three reasons for its potency as a witch antidote: its aura of powerful magic; its reputation for holiness; and its red berries, for no witch could face red (fire) in any form.

Superstitions and Christmas

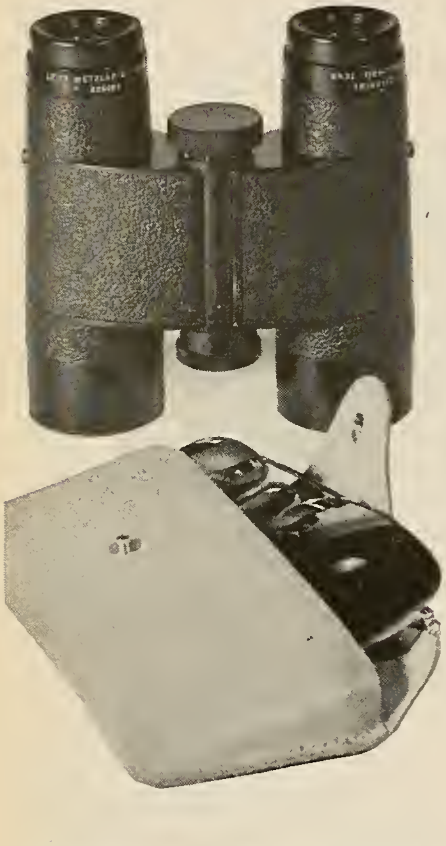
Inevitably, many superstitions grew up about holly, particularly in connection with the Christmas festivities. Green (fresh) holly must never be burned: to do so may result in a death in the house. Nor must it be brought into the house for decoration before Christmas eve. Equally important, it should be taken down before Twelfth Night (January 6) with all the other Christmas greens, or the dire result will be a houseful of goblins. The poet Robert Herrick (1591-1674) is most insistent about this:

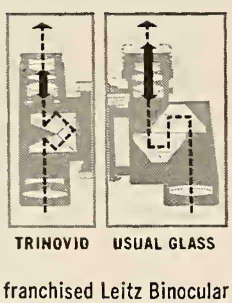
Down with the rosemary, and so
Down with the Baies and Mistletoe;
Down with the Holly, Ivie all
Wherewith ye dressed
 the Christmas Hall.

That so the superstitious find
Not one least branch left there
 behind:
For look, how many leaves there be
Neglected there, maids trust to me
So many goblins you shall see.

It is unlucky to stamp on holly berries or to bring holly into the house when it is in flower. If the first person to enter a house on New Year's day should bring a branch of holly with him, he must make sure it is the male species, as anything female will bring bad luck to the house. *Poor Robin's Almanack* for (Christmas) 1695 tells how "With holly and ivy so green and so gay, We deck up our houses so fresh as the day."

Its popularity as the main Christmas decoration has never lessened and has





been sung down the ages. The old ballad "The Mistletoe Bough," by Thomas Haynes Bayly (1797-1839), which was a tremendous favorite in Victorian days, begins:

> The mistletoe hung in the castle hall,
> The holly-branch shone on the old oak wall.

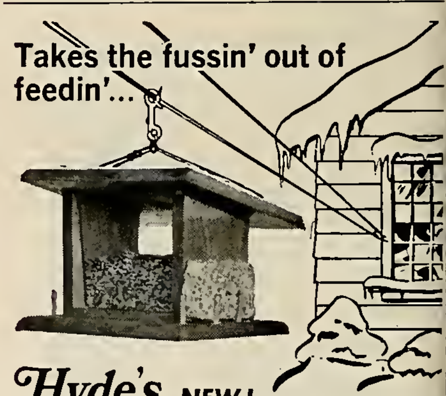
It goes on to commemorate the [true] holiday tragedy of the bride who disappeared on her wedding night at her home in Oxfordshire, England. The wedding party were playing hide-and-seek, and the unfortunate girl hid in a large oak chest in an unused room. It had a snap lock and the lid fell; many years after, her dead body, in the remnants of her wedding finery, was discovered. It was a tradition even in my childhood for this mournful saga with its particularly dreary tune to be played or sung every Christmas eve, the anniversary of the tragedy.

Another tradition was that man could invoke the ancient magic of holly on Christmas eve to disclose the seeker's future matrimonial fate. This charm comes from the English north country. Gather nine female holly leaves, tie with nine knots in a three-cornered handkerchief, and lay under the pillow when going to bed. The future husband or wife will then appear in a dream. This charm will work only if silence is maintained from the moment of setting out to gather the leaves until dawn the next day. It should be noted here that not only the holly's own magic is vital but also the power of the mystical numbers nine and three, which are almost invariably invoked in any charm or spell. If you want to grow holly, be sure you have both the male and female species in the garden or there will be no berries to sow.

Medicinal Properties

Holly does not appear prominently in medical history. Nicholas Culpeper, the great herbalist-physician (1616-1654), lists it, although his even greater predecessor John Gerard (1545-1612) apparently did not use it. Culpeper describes it as follows:

> HOLLY. HOLM OR HULVER. Bush (Ilex aquifolium)
>
> DESCRIPTION. This is a well-known large bush. The bark is whitish on the trunk, but the young shoots are green. The leaves are oblong irregular at the edges and prickly. The flowers are greenish and the berries black. Another species has thinner leaves and yellow berries.
>
> PLACE. This is often planted as a garden-hedge.
>
> TIME. It flowers in May.
>
> GOVERNMENT AND VIRTUES. The Tree is Saturnine. The berries expel, and



are profitable in the colic. If you eat a dozen of them in the morning fasting, when they are ripe and not dried they purge the body of gross and clammy phlegm; but if you dry the berries and beat them into a powder they bind the body and stop fluxes and the terms in women. The bark and leaves also are excellent being used in fomentations for broken bones and such members as are out of joint.

It is curious that Culpeper speaks of the berries as black, and that although he does mention the yellow kind he says nothing of the far more common red berry. There is a variety with black berries, although it is not generally listed in books on trees. However, Mrs. Jane London, a Victorian authoress and an expert on gardening, speaks in her book *The Ladies' Companion to the Flower-Garden*, published before 1845, of holly berries being red, white, yellow, and even black. Perhaps the black berries may have been more common 200 years previously, or possibly Culpeper found them more effective.

One other medicinal use for holly still employed today is as a cure for chilblains. The treatment consists of beating the hands or feet with bunches of prickly holly. The original reason given was that the magic in the holly would drive out the chilled blood; the more prosaic reasoning of our own age is that it helps the circulation. Still, if there were no belief in the holly's magic, why doesn't the sufferer use a stiff brush, which should be just as effective?

There is no need to remind readers of NATURAL HISTORY of the botanical importance of holly. Of the family Aquifoliaceae (genus *Ilex*) it has nearly 200 species distributed throughout the five continents, although it is not common in Africa or Australia. As a protector of the garden (apart from its magic properties!) a holly hedge is beyond compare; neither cat, dog; nor boy will penetrate it. Except perhaps in the sad case of the most famous holly hedge in history—400 feet long, 9 feet high, and 5 feet wide—which grew at Sayes Court, the home of John Evelyn, the diarist (1620-1706). The hedge was Evelyn's pride and joy, but unfortunately he rented his house to Peter the Great of Russia when he was on a visit to England. That eccentric potentate amused himself by being constantly driven backward and forward through the holly hedge in a wheelbarrow. Not surprisingly the hedge was ruined!

Dorothy Jacob, a British author, wrote "A Witch's Guide to Gardening" and "Cures and Curses." The latter deals with the extraordinary uses of plants and animals in the history of cures.

Instinct and aggression

By T. C. Schneirla

Evolution and Modification of Behavior, by Konrad Lorenz. *The University of Chicago Press, $3.50; 121 pp.* On Aggression, by Konrad Lorenz. *Harcourt, Brace & World, $5.75; 306 pp.*

Dr. Lorenz, Director of the Max Planck Institute for Physiology of Behavior, Germany, and the author of works on animal behavior, has written two new books on important subjects. In *Evolution and Modification of Behavior* he discusses his theory of animal behavior; in *On Aggression* he applies this theory to a problem in social behavior. Both books stem from dubious assumptions.

Aggression is defined as "The fighting instinct in beast and man which is directed against members of the same species." The thesis for man and beast alike is: Aggressive instincts dominate behavior unless curbed. The importance of this point for man is stressed: Someone from another planet, "looking upon man as he is today, in his hand the atom bomb, the product of his intelligence, in his heart the aggression drive, inherited from his anthropoid ancestors, which this same intelligence cannot control, would not predict long life for the species."

Instinctual aggression is, of course, not a new concept. Its dominance in natural selection is an idea Lorenz shares with Herbert Spencer (first to speak of "survival of the fittest") and Freud. Lorenz considers aggression and fighting common and thinks they must have been potent in the evolution of all animals.

On Aggression opens with vividly described observations of strikingly colored coral reef fishes in tanks and in the sea. In each case a territory holder, excited by an invader of his own species, drives off the trespasser. Territorial defense fighting, common in lower vertebrates, birds, and mammals, is found crucial as a basis for food getting, mating, rearing young, and other behavior promoting species survival. In lower animals, instinctive aggression is viewed as working well; in man, however, it seems to be getting out of hand.

Mechanisms that inhibit fighting, Lorenz holds, are essential to survival in lower animals and man alike. Chief among these are ritualistic displays in which aggressors are warded off with little or no combat. In man, however, the inhibitory controls imposed on aggression both through natural selection and through cultural processes may fail in the split-second emergencies created by modern weaponry and accessory bellicose patterns. Man is "the only being capable of dedicating himself to the highest moral and ethical values" but one "whose animal properties bring with them the danger that he will kill his brother, convinced that he is doing so in the interests of these very same high values. *Ecce homo*!" Behold man, that is, as Lorenz sees him.

Lorenz shares this somber view with Freud, who also saw conflict and war as inevitable, violent expressions of irresponsible, aggressive instincts. Lorenz, like Freud, considers the social bond and related influences inadequate to inhibit man's aggressive biological nature in the modern world.

In his chapter "Avowal of Optimism," Lorenz suggests that, under the described threat, we must find methods for ritualizing and channelizing instinctive aggressions, must encourage people of differing ideologies and races to get acquainted, must direct "the militant enthusiasm" of youth toward "genuine causes that are worth serving in the modern world," and must improve our understanding of behavioral mechanisms fundamental to aggression, the better to control them. We must use all our resources of humor and of knowledge to these ends. These suggestions, although helpful, seem to reveal an aspect of Freudian sublimation—making the best of a bad deal.

A different picture of man, however, based on current scientific methodology and theory, is at odds with Lorenz' outdated negative view. Results of research on human group behavior emphasize man's great social potentials arising from his developmental plasticity and his versatility for constructive behavior. At the same time, evidence on the origins of asocial behavior suggests that those hypotheses in which instinctual aggression explains the rise of wars are tangential and naïve.

The question is, not whether results concerning behavior in lower animals are applicable to man, but whether the application is as simple a matter as Lorenz' procedures imply. Responsible scientists must carry out their behavioral research within the broadest perspective and evaluate evidence in terms of the most valid theory possible. Evidence on individual differences, on the conditions of development, and on the state of the population must be featured, for

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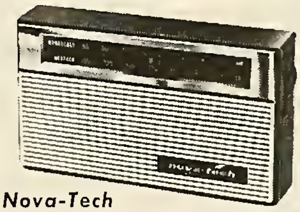

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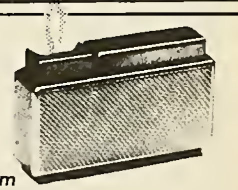

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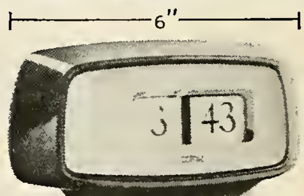

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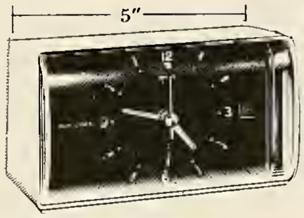

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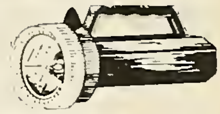

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these surely were all crucial in the natural selective background of every animal. The results of research must be presented in comprehensive reports open to searching analysis, not in descriptive, subjective terms as Lorenz has done.

The significance Lorenz gives his results is too great to justify his non-experimental, anecdotal treatment of the subject. An appropriately broad, systematic presentation of the behavioral facts would have aided readers to understand, for example, how differently individual fish responded according to the conditions (as stressful crowding in aquariums), and how results from observations of animals in confinement actually compared with the behavior of species mates under natural conditions.

Studying social phenomena and other behavior under natural conditions is extremely important, and the ethological approach inspired by Lorenz and Tinbergen has aided such work, which ideally goes hand in hand with laboratory research. The field of behavorial development is highly controversial, however, in ways that do not emerge clearly in *Behavior*. Lorenz' critics dispute neither his emphasis on "the great fact of adaptiveness in behavior" as he implies, nor on the correlations between genotypes (empirically described species genetics) and phenotypes (individual patterns developed). Rather, they reject much of his evidence as partial and unreliable, and question the assumptions he applies dogmatically to these problems.

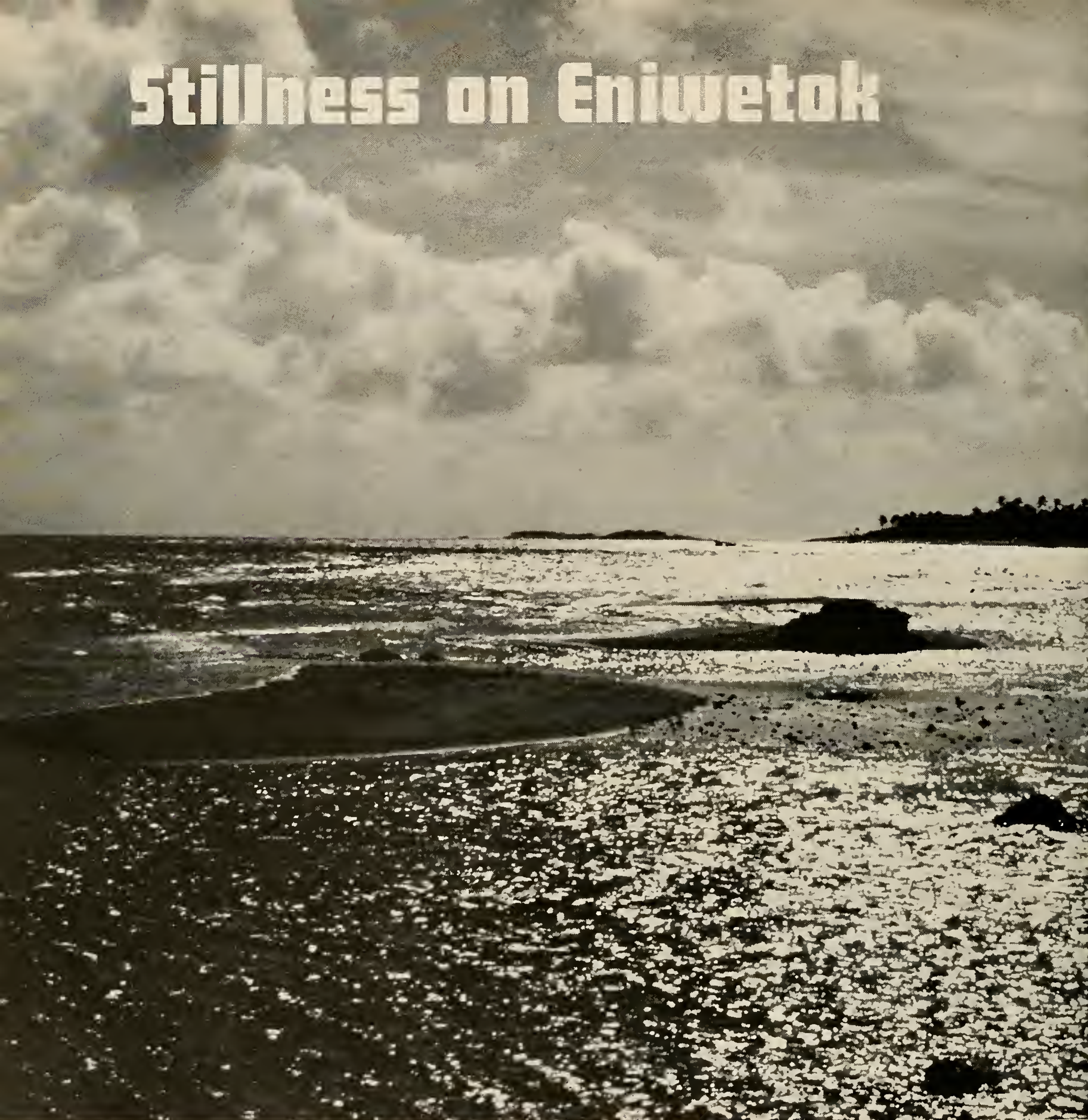
It is not clear from *Behavior* whether or not science will be aided by Lorenz' terms, "phyletic information" and "individually acquired information," which he consistently confuses with reality. These concepts, notwithstanding the impressive cybernetic aura he gives them and the polemical deftness with which he uses them, seem not to differ much from their traditional synonyms, "nature" and "nurture," respectively.

Space precludes discussing the obfuscations raised in *Behavior* for readers attempting to judge the theoretical issues involved in the book. Lorenz admits that the terms "innate" and "learned," used (by "earlier ethologists") to denote mutually exclusive agencies, are fallacious. But at the same time, in speaking of "information" that is either "phyletically acquired" or "individually acquired," he revives the fallacious dichotomy by using the word *information* in two different senses. He repeats his old assertion that others (whose evidence and ideas he evades) offered "learning in the egg and *in utero*" to explain ontogenesis, although he should know by now that this is both an untrue statement and a misrepresentation of important evidence.

Two related devices stand out in the

Continued on page 60

Stillness on Eniwetok



A young biologist's impressions of island life

Eniwetok Atoll is a horseshoe of sand islands and reefs, 10 hot degrees north of the Equator among the Marshall Islands of Micronesia. Here the sun is dazzlingly bright; the sunsets brief, but beautiful. Here an observer can catch a glimpse of the traditional tropical paradise of sparkling seas and swaying coconut palms. But only a glimpse, for Eniwetok has witnessed some of the most savage events of this century.

The atoll, like others in the Pacific, is a coral reef, alive and growing, responding almost as a unit to the daily measure of light from the sun. It rests on a cone of dead coral a thousand feet thick, which in turn covers the top of a submerged mountain several miles high. The reef encloses a lagoon that, although it is as much as twenty-five miles wide, is no more than a couple of hundred feet deep. Where the reef projects above the surface of the water, small islands of sand have formed; where the sand is deep enough, some bushes and trees have grown, depositing a soil of sorts above the sand and providing a habitat suitable for humans.

The first people to settle on the atoll came from the great melting pot of Southeast Asia. Negrito, Vedda, Caucasoid, and Mongol mixed in Malaya and Indonesia, and under the steady Mongol pressure from the

By Michael Berrill

at a former nuclear test site

north, began to emigrate across the Pacific more than fifteen hundred years ago. They came in successive waves, some as much as centuries apart. One of the later waves remained in Micronesia instead of moving on to the larger, more hospitable islands of Polynesia.

The Marshall Islands were unrecorded in the West until Captain Marshall, returning to England with a cargo of Cantonese tea in place of the British convicts he had deposited at Botany Bay, sighted them in 1787. But for a hundred years afterward the islands represented little more than dots on European maps, telling of reefs that sailors should avoid. The inhabitants, the Marshallese, led placid lives in the meantime. They grew coconut palms in plantations where the soil was thick enough, and they fished from the abundant reefs in the lagoons. Like other Micronesians, they traveled in all directions to neighboring atolls. They remained, despite such a predilection for travel, free of other societies until the 1870's, when they were absorbed into the expanding German Empire and their copra trade came under German management. In 1920, a League of Nations mandate gave control of the Marshall Islands to Japan. It, in turn, supervised the copra trade until the islands were closed off from the rest of the world in preparation for World War II.

The Marshallese of Eniwetok were forced to accept first the Germans and then the Japanese. During the Second World War they moved to the northern islands of the atoll, away from their homes on the larger southern ones, fleeing a war that concerned a world of which they had little conception. In February, 1944, 200 Americans were killed in the successful capture of Eniwetok Atoll—a battle in which, according to their orders, 2,600 Japanese died in a struggle they could not have hoped to win. All for an atoll that has only two and a half square miles of sandy land exposed when the tide is high.

With the war's end, the Marshall Islands came under United Nations trusteeship with the United States appointed to guide them in their own interests. The civilian-controlled U.S. Atomic Energy Commission, created in 1946 to supersede the U.S. Army Corps of Engineers' Manhattan District (the agency that guided the development of the atomic bomb), sought a testing site that was sufficiently isolated from large concentrations of human population and that had a warm and relatively stable climate. The site also had to be located where detonation would not severely harm commercial fisheries. The Marshalls, minute atolls in the largest of oceans, looked ideal and were finally selected. The Marshallese living too close to the test area were moved to other atolls before testing began, which occurred first at Bikini and then at Eniwetok Atoll. In 1952 the first thermonuclear bomb was exploded on a small island at the northern end of Eniwetok. Henceforth—except for highly controlled situations—radiation from nuclear bomb tests would no longer be limited to local ecosystems, but instead would enter the atmosphere of

Often on Igurin a White Fairy Tern hovers silently several feet above the head of a visitor and simply stares at him, sometimes for minutes.

the earth and be dispersed globally.

Several detonations followed in 1954, including the well-publicized explosion at Bikini that came to involve the crew of a Japanese fishing boat. But since the 1958 Geneva Test Ban Agreements, the atolls have been silent. In fact, by 1961 the Atomic Energy Commission had lost interest in the atolls and had transferred control of them to the U.S. Department of Defense for development in the Pacific missile range. Curiously, the atolls have returned to the jurisdiction of a military agency.

Despite the events of the last forty years, there are several islands of Eniwetok Atoll that have remained largely undisturbed by war, nuclear tests, and military installations. One of these is Igurin Island, and only the regular rows of coconut palms in the overgrown plantations tell of a time when the island was known and cultivated by the Marshallese. Today it has no inhabitants. Instead, it has palm trees, sunshine, sand, and sea, and most of the animals that are associated with a tropical coral island. Here, indeed, is that glimpse of paradise where one must discard his own civilization so that he may feel a part of what he sees.

The coconut palms dwarf the rest of Igurin's vegetation, their fronds swaying and rattling in the winds. Once these trees fed, clothed, and housed the natives, but now the coconuts fall to the ground to rot or to be eaten by island scavengers. A low silver-barked tree, *Pisonia,* typical of atoll growth wherever there is sufficient soil, and the scrub bushes *Scaevola* and *Messerschmidia* cover most of the island. The bushes and trees are the nesting sites for two tropical species of terns, and Igurin is a home for thousands of each.

The two kinds of terns nest and roost peacefully together and fish together offshore. They may join forces to mob a heron or a frigatebird that approaches too near the nesting sites, and both try to discourage a human intruder by diving at him, veering off almost reluctantly only at the last second. One is the Noddy Tern, a dusky, chunky bird. The other could hardly look more different. It is a smaller bird of fine proportions, totally white except for black eyes and bill, and named, most appropriately, the White Fairy Tern. Each lays only a single egg in its nest, but the Noddy often builds its nest on the ground, whereas the Fairy nests exclusively in the trees. The White Fairy Tern is the more

A Sally Lightfoot scampers off to the protection of the water. At right, ghost crab excavations line a portion of beach above high-tide level.

curious, often hovering a few feet over an intruder and cocking a black eye at him. It is also the more playful, for pairs often fly, soar, chase, and tumble together over the island. Yet in all this—fishing, dive-bombing, mobbing, curiosity, and play—the White Fairy and Noddy Terns are strangely silent. A hundred birds may jump into flight, but only the beating of their wings is heard against the perpetual background of wave and wind.

The nesting sites of sea birds throughout the world's tropical oceans are among the favorite hunting grounds of the impressive frigate-bird. Igurin is no exception, for every day five or six frigate-birds soar effortlessly above the island for hours on end, scarcely moving a wing as they rise and fall with the air currents. With an eight-foot wingspread and a deeply forked tail used for steering and braking, the frigates are known as the most acrobatic of birds, reputed to steal food from other flying sea birds, to catch flying fish in mid-air, and to sweep in on nesting sites of boobies, terns, or even other frigate-birds and snatch up unwary chicks. Of all the birds that fly beautifully, the frigates appear to take the most pleasure in their own movements. They are unparalleled in the air; there they rule.

Other birds visit Igurin. Boobies occasionally fish off the edges of the reef; the solitary Reef Herons stalk the shallow reef waters; the Ruddy Turnstone and Bristle-thighed Curlew search the water's edge.

There is little other daytime activity on the island. Living in the leaf litter is one of the more elusive of the inhabitants, the small blue-tailed skink, a darkly polished lizard with long golden stripes along its back. It hunts for insects in the litter, racing with extraordinary agility from the slightest disturbance. It is not often caught unawares, for it has a small transparent window in the center of its lower eyelid through which it can detect movement when the eyelids are shut, an adaptation that many skinks have for eye protection and vision while burrowing.

At night all is usually still on Igurin. The terns roost silently in the trees. Occasionally a White Fairy Tern is aroused from its perch and, in the darkness, slowly picks its way through the branches, its wings frantically beating. More often, the birds remain undisturbed. Only the nocturnal scavengers are active, exploring the undergrowth for anything that can be eaten.

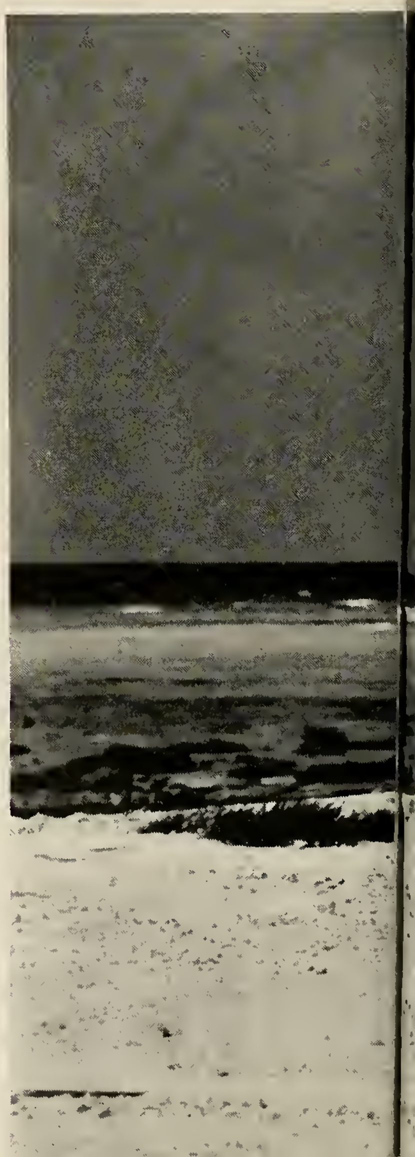
One of these scavengers is the small, brown Polynesian rat, which now lives on islands throughout the Pacific. It spread from island to island on floating rafts and in native canoes, and it has prospered on the fruit of the palm trees, climbing for the young fruit or eating those fallen and broken on the ground. The Eniwetok population of this little rat has become justly famous since the testing of the hydrogen bomb. The bomb was detonated over one of the small, almost barren sand islands at the north end of the atoll. It produced, until the sediment began to resettle, a crater two hundred feet deep where the island had been only moments before, and it sent a great wave of water to swamp adjacent islands. The size and effects of the blast were far vaster than anyone had anticipated. The blast and its wave of water killed the vegetation of the nearer islands, left their sea birds sick and dying, and covered the sea with dead reef fish. Strangely enough, when damage on the islands was being carefully surveyed, a few rats were discovered still alive and unhurt where all else had been destroyed. The time since the blast was too short and the distance from the unaffected islands too long for new rats to have repopulated these islands. How they survived no one knows for certain. Perhaps they were protected by their burrows or by the foundations of some of the military installations, but some had lived.

The rats on Igurin share the fallen coconuts with that most magnificent of crabs, the coconut crab. Steel blue, with long legs and viselike pincers, sometimes six inches across the carapace and as much as a foot and a half long, the coconut crab was once a source of meat for the Marshallese. The testing of the bomb, however, changed this. New scrub vegetation and new populations of sea birds and fish have replaced some of what was killed, and the radioactive contamination of the water and its organisms has become sufficiently diluted to be quite safe. But the coconut crab has continued to concentrate small amounts of the radioactive isotope of

Its legs securely hugging the trunk, a coconut crab shins up a coconut tree. In the Marshalls, the crab is radioactive and unsafe to eat.

A land hermit crab, Coenobita, *is about to feed on a fallen coconut. The opening in the fruit has been neatly incised by claws of coconut crab.*

The spotted egg of a Noddy Tern lies among shells, pebbles, and driftwood in a loosely built ground nest. The Noddy is a dark, chunky bird, which, like the White Fairy Tern, fishes both in lagoons and the open ocean.



the trace element strontium, and so is unfit to be eaten.

Safe from human predation, at least on Eniwetok, the coconut crab, nevertheless, remains a shy creature. It is able to live only on islands where there is vegetation and where men seldom come, and Igurin is such an island. Here hundreds of coconut crabs roam the undergrowth every night. When one is attacked or annoyed, it backs off in rapid spurts, clapping its abdomen sharply under the rest of its body. Normally, it plods slowly forward, only occasionally climbing *Pisonia* or coconut trees. No one has ever seen a coconut crab actually cut a coconut from a treetop; perhaps it climbs the trees to eat young leaves. However, the shredded husks and neatly broken shells of the fallen coconuts are evidence of the dexterity of the crab, which pulls off the fibers of the husk in thin strips and then breaks open the hard shell by inserting the fine finger of its claw into one of the soft eyes of the nut and starting to cut from there. What the coconut crab doesn't eat of the coconut meat, rats, hermit crabs, and insects undoubtedly do, although the rats are quite capable of gnawing their way to the meat by themselves.

When they are not searching for food or for members of the opposite sex at night, the crabs live in burrows under tree roots or rocks—wide burrows sometimes several feet deep. Although they are land crabs, they begin life as marine larvae that settle on the ocean bottom and live for awhile like typical hermit crabs, occupying the empty shells of small marine snails. Later they leave the sea and crawl up the beach into the woods, retaining their shells until the crabs grow too large and too tough to need them any longer. During the summer the adult female bears a great cluster of orange and purple eggs under her abdomen, and when they are ripe she leaves the woods, crosses back down the beach, and dips her abdomen into the water. Instantly, the ripe eggs hatch and the larvae swim away, while the eggs that are not yet ripe remain attached and intact.

The coconut crab is not alone on Igurin as an emigrant from the sea. The land hermit crab, *Coenobita*, pokes about in the undergrowth scavenging for food, but can only eat coconuts that have already broken open. When the season is right—the time of the new moon in midsummer—hundreds of these bright-red animals gather on the beach late in the evening for a night of communal mating, raising a clat-

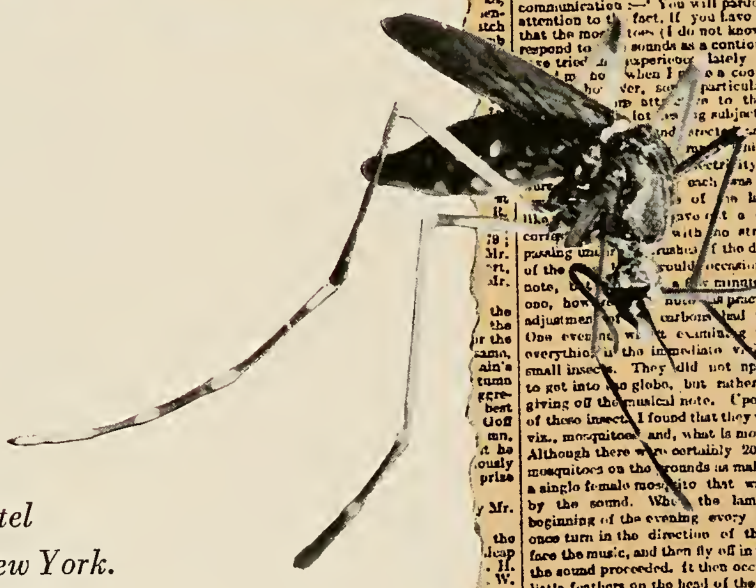
ter of bumping shells. The occurrence of such an evening seems to bear some relationship to moon phase and day length, a relationship that bespeaks a strong internal physiological clock and results in the reproductive synchrony so important for the success of the species.

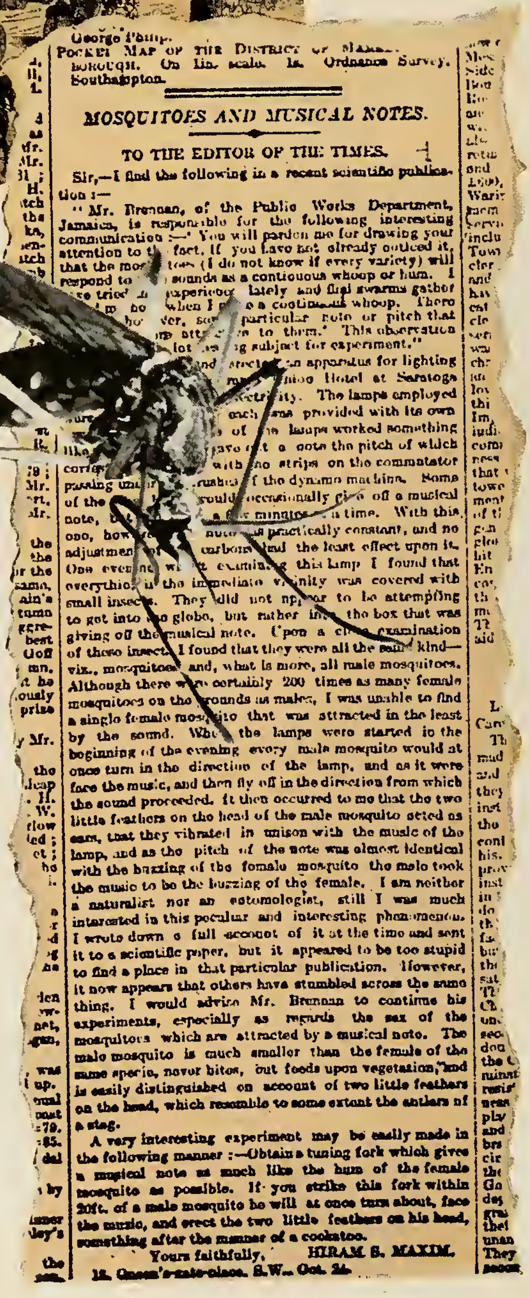
A proper sideways walking crab often wanders along the shore at night, but the moment it is disturbed it careens madly away across the rocks to the security of the water, barely touching the ground, and because of its swiftness earning its common name, Sally Lightfoot. And ghost crabs—fast, silent, and pale—dance along the water's edge during the night, returning at dawn to their burrows in the sand above the high-tide level. Neither crab competes with the land hermit crab or the coconut crab for the food of the underbrush. Their smaller claws and their fleetness of foot render them more adapted to searching for organisms along the beach and rock ledges, and neither can tolerate prolonged exposure to the drying winds.

All four of these crabs are shy, yet each is unique. Each has its own particular habitat, its own means of defense and feeding, its way of homemaking, its own specific sexual behavior. To varying extents these crabs represent an escape from the sea onto land: the coconut crab leaving it most completely, Sally Lightfoot never far from its safety. They are the link between the world of heat and light, sand and palm trees, and the very different world of the sea and its reefs.

The coral reef community is one of the richest and most complex on earth, for here a vast array of animals make use of an abundance of niches. The reefs of Eniwetok are no exception. Corals grow in strange shapes and sizes; plumed tube worms withdraw abruptly at the slightest passing shadow; giant clams wedge securely in the coral heads, exposing only their brilliant mantles; reef fish with extraordinary colors flit among the corals; and large, solitary fish, including sharks, quietly search the reef for food.

Beneath the surface of the tropical sea all is cool and nearly silent. Above it is the heat, the brightness, and the dryness of another world. Each evening brings a sunset more beautiful than the last; each day brings, amidst the heat and brightness, a rainstorm to rival the torrential downfall of the day before. Rarely is there a day without a trade wind to make the heat bearable, and every night when the moon is not up, it seems as black as night could ever be. Here, once again, the universe and its nature is the way it has been for eons, essentially untouched and unchanged by humanity. Here a man's footprint, however deep, soon washes away.





George Philip.
POCKET MAP OF THE DISTRICT OF [illegible] BOROUGH. On 1in. scale. 1s. Ordnance Survey, Southampton.

MOSQUITOES AND MUSICAL NOTES.

TO THE EDITOR OF THE TIMES.

Sir,—I find the following in a recent scientific publication:—

"Mr. Brennan, of the Public Works Department, Jamaica, is responsible for the following interesting communication:—'You will pardon me for drawing your attention to th[illegible] fact, if you have not already noticed it, that the mos[illegible]toes (I do not know if every variety) will respond to [illegible] sounds as a continuous whoop or hum. I [illegible] tried [illegible] experience lately and find swarms gather [illegible] when I [illegible] a continuous whoop. There [illegible] ho[illegible]ver, so[illegible] particular note or pitch that [illegible] attr[illegible] to them.' This observation [illegible] lot [illegible] subject for experiment."

[illegible] and erected an apparatus for lighting [illegible] Union Hotel at Saratoga [illegible] electricity. The lamps employed [illegible] each [illegible] provided with its own [illegible] of the lamps worked something like [illegible] gave out a note the pitch of which corre[illegible] with the strips on the commutator passing un[illegible] brushes of the dynamo machine. Some of the [illegible] would occasionally give off a musical note, [illegible] a few minutes at a time. With this one, how[illegible] note was practically constant, and no adjustment of [illegible] carbons had the least effect upon it. One evening wh[illegible] examining this lamp I found that everything in the immediate vicinity was covered with small insects. They did not appear to be attempting to get into the globe, but rather into the box that was giving off the musical note. Upon a close examination of these insects I found that they were all the same kind—viz., mosquitoes, and, what is more, all male mosquitoes. Although there were certainly 200 times as many female mosquitoes on the grounds as males, I was unable to find a single female mosquito that was attracted in the least by the sound. When the lamps were started in the beginning of the evening every male mosquito would at once turn in the direction of the lamp, and as it were face the music, and then fly off in the direction from which the sound proceeded. It then occurred to me that the two little feathers on the head of the male mosquito acted as ears, that they vibrated in unison with the music of the lamp, and as the pitch of the note was almost identical with the buzzing of the female mosquito the male took the music to be the buzzing of the female. I am neither a naturalist nor an entomologist, still I was much interested in this peculiar and interesting phenomenon. I wrote down a full account of it at the time and sent it to a scientific paper, but it appeared to be too stupid to find a place in that particular publication. However, it now appears that others have stumbled across the same thing. I would advise Mr. Brennan to continue his experiments, especially as regards the sex of the mosquitoes which are attracted by a musical note. The male mosquito is much smaller than the female of the same specie, never bites, but feeds upon vegetation, and is easily distinguished on account of two little feathers on the head, which resemble to some extent the antlers of a stag.

A very interesting experiment may be easily made in the following manner:—Obtain a tuning fork which gives a musical note as much like the hum of the female mosquito as possible. If you strike this fork within 20ft. of a male mosquito he will at once turn about, face the music, and erect the two little feathers on his head, something after the manner of a cockatoo.

Yours faithfully, HIRAM S. MAXIM.

18, Queen's-gate-place, S.W., Oct. 24.

In the late 1800's,
Hiram Maxim
was commissioned
to light the grounds
of the Grand Union Hotel
in Saratoga Springs, New York.
While installing electricity,
he had occasion to speculate on
the beating wings of mosquitoes.
Since scientific journals of
the day were uninterested
in his observations, he had to
"publish" in the letters column of
The Times *of London. Recent work takes up*
where he left off and inquires into the
role of sound in the life of the mosquito

The Allure of the Female Mosquito

By Marc Roth, L. M. Roth, T. E. Eisner

In 1878 I made and erected an apparatus for lighting the grounds of the Grand Union Hotel at Saratoga Springs, New York, by electricity. . . . One of the lamps worked something like a telephone and gave out a note . . . . One evening whilst examining this lamp I found that everything in the immediate vicinity was covered with small insects. They did not appear to be attempting to get into the globe, but rather into the box that was giving off the musical note. Upon a close examination of these insects I found that they were all the same kind—viz., mosquitoes, and, what is more, all male mosquitoes . . . . I was unable to find a single female mosquito that was attracted in the least by the sound."

This excerpt is from a letter that appeared in *The Times* of London on October 28, 1901. The author—evidently a keen observer—was a gentleman by the name of Sir Hiram Maxim, a versatile engineer whose varied claims to fame include the invention of the machine gun. Although Maxim confessed to being neither a naturalist nor an entomologist, he wrote a full account of his observations and submitted it to a scientific journal. Unfortunately, the account "appeared to be too stupid to find a place in that particular publication," so Maxim had to publish in the form of a letter to *The Times.* His letter continues:

"When the lamps were started in the beginning of the evening every male mosquito would at once turn in the direction of the lamp, and as it were face the music, and then fly off in the direction from which the sound proceeded. It then occurred to me that the two little feathers on the head of the male mosquito acted as ears, that they vibrated in unison with the music of the lamp, and as the pitch of the note was almost identical with the buzzing of the female mosquito the male took the music to be the buzzing of the female."

To test his ideas, Maxim obtained a tuning fork whose pitch mimicked closely the hum made by the female mosquito in flight. Whenever he struck the fork close to a male, he saw the insect "at once turn about, face the music, and erect the two little feathers on his head, something after the manner of a cockatoo."

Today, Maxim would have had no difficulty publishing his results in a more formal manner. Animal behavior is an established field, with countless investigators throughout the world attempting to discover the particular ways that organisms interact with each other and with their environment. Since 1900 numerous casual observers have referred to the attraction of male mosquitoes to sounds. Some noticed that the insects could be lured to musical instruments when notes within a certain frequency range were played: others even purported to attract them with the human voice. A few years ago, L. M. Roth, one of the writers, had the chance to investigate the problem in some detail, and other researchers later made additional studies. Maxim was correct, both in his observations and in the conclusions he drew from them: male mosquitoes are attracted to the sounds made by the wings of female mosquitoes in flight. and this is indeed the way that males and females come together in nature to mate. But the full story is more complicated and more interesting.

The notorious carrier of the yellow fever virus is *Aëdes aegypti.* Because it is easily reared indoors and able to withstand drastic experimental manipulation, this mosquito makes an ideal laboratory subject.

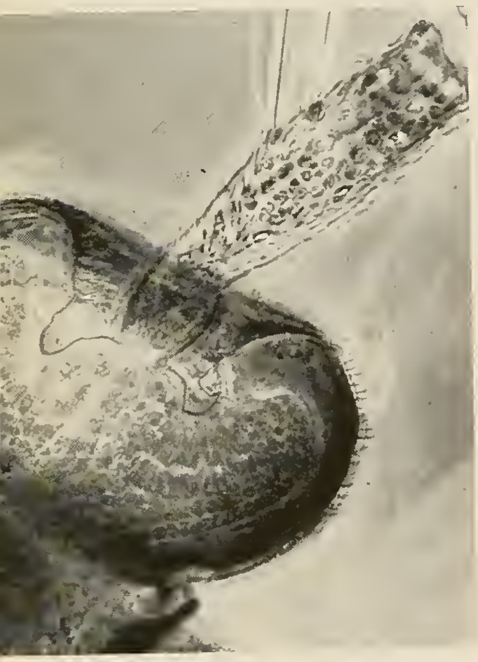
In *A. aegypti*, as in the species observed by Maxim, mating is initiated in flight. Males are attracted to sounds between frequencies of 300 and 800 cycles per second. The beating wings of females emit sounds varying from 450 to 600 c.p.s., falling clearly within the range that lures the males. The sensitivity of the male to volume is not especially great: if the female is more than ten inches away, the male usually ignores her.

The role of sound in attracting the males can be demonstrated not only with such artificial sound sources as tuning forks but also with live females tethered to wires and introduced into caged populations of males (*see pages 30 and 31*). Tethering is accomplished by first anesthetizing the female with a jet of carbon dioxide, then cementing the tip of a fine wire to the back of her thorax. Care must be taken to insure that the cement will not interfere with the motion of the wings. Once recovered from her "sleep," she beats her wings as in normal flight, suspended from the wire like a minute aerial performer.

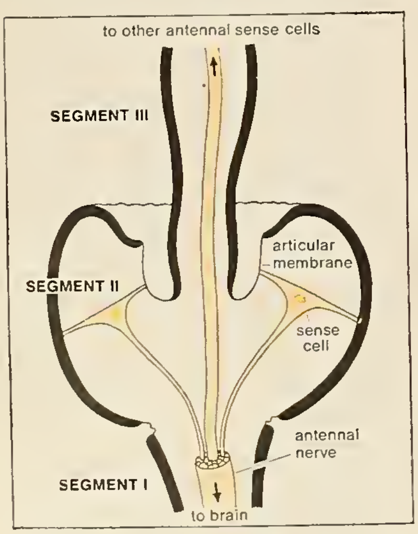
Such a tethered female is attractive only as long as her wings are in motion. Males fly toward her, seize her from beneath, and mate with her. This procedure lasts only a few seconds, and is no different from what ordinarily takes place in nature. If the wings are amputated or immobilized with cement, or if the female should, on her own initiative, momentarily rest her wings, she is left with no allure. Even at close range, the males simply fly past her as if she were not there.

Males must have their antennae in order to respond to females. Removal of antennae (antennectomy) is easily accomplished under anesthesia by

The swollen segment at the base of the antennal shaft contains sound receptor cells and is the "ear" of male mosquito.



Cross section shows outline of articular membrane (also diagramed below), which aids in vibration transmission.



Sound deforms membrane, which causes receptor cell to send impulse to brain.

severing them with a sharp scalpel. Males treated in this fashion are, for all intents and purposes, deaf.

The "ear" of the male (*shown at left*) is a structure of considerable interest and can be understood only by examining the antennae in some detail. Each antenna is essentially a flexible shaft, consisting of fifteen hinged segments. The second segment from the base is conspicuously swollen and houses the actual receptor cells that perceive sound. These cells are stretched between the rigid outer wall of the segment and the thin articular membrane by which the segment connects with its distal neighbor (segment three). Any vibration set up in the antennal shaft by sound waves impinging on it will cause the articular membrane to be rhythmically deformed; this in turn forces distortions upon the receptor cells. In response to such distortions, the cells release bursts of nerve impulses that are channeled, via the antennal nerve, to the brain and eventually, by way of the nerve cord and appropriate motor nerves, to the muscles. The particular rhythm with which the antennal shaft vibrates is obviously a function of the frequency of the impinging sound waves. If the sound is that of the flying female, the nervous system "recognizes" it as such and sets in motion the train of events that leads to pursuit of the mate and copulation. Thus, the elaborate business of reproducing the species is essentially triggered by a signal no more complicated than a simple musical note.

One of our conclusions was actually drawn with some risk of error. Although antennectomy abolishes the response to sound, does this actually

On the head of newly emerged male mosquito (genus Aëdes) antennal bristles lie recumbent against main shaft. The proboscis is in center, flanked by the palpi.

prove that the male hears with his antennae? One might argue, for example, that although without antennae the male does not react to the female, he is still able to hear her. However, one need not resort to antennectomy to remove the sound response. If the antennae are weighted at their tips, or if they are immobilized with glue, the male also behaves as if he were deaf. In other words, it is the antenna's ability to vibrate that is important. This adds considerable support to the belief that the elaborate sensory apparatus at the base of the antenna, whose very construction suggests that it must serve for vibration detection, is indeed the mosquito's auditory organ.

Comparison of the antennae of male and female brings to light a striking difference. While the female has antennae that are almost naked, those of the male are densely covered with bristles. These bristles are an important adjunct to the hearing apparatus. They are not indispensable for hearing, since they can be removed and the male still responds to tuning forks. But without them sensitivity to sound is drastically reduced, and the male may no longer react to the weak hum of its mate. The bristles evidently serve to "collect" the sound, and act in the manner of an amplifier system. Without bristles, the antenna is like a mast without its sail, unyielding in a breeze.

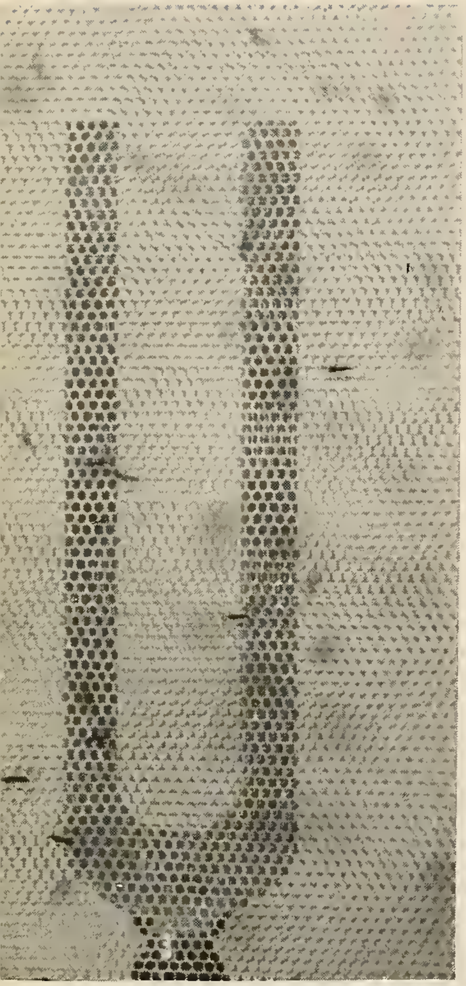
There are other features of the reproductive behavior of *Aëdes* that are related to its habit of communicating by sound. When the male first emerges from the pupa, he is sexually incompetent. This is because his genital apparatus, consisting of an intromittent organ and various accessory structures, is oriented upside down. The proper orientation is not assumed until about two days later. During this period, the entire tip of the abdomen, together with the genital apparatus that it bears, undergoes a gradual rotation of 180 degrees.

When male is several days old and sexually mature, the bristles on the antennae become erect. In this condition they are able to "collect" the sound of the female.

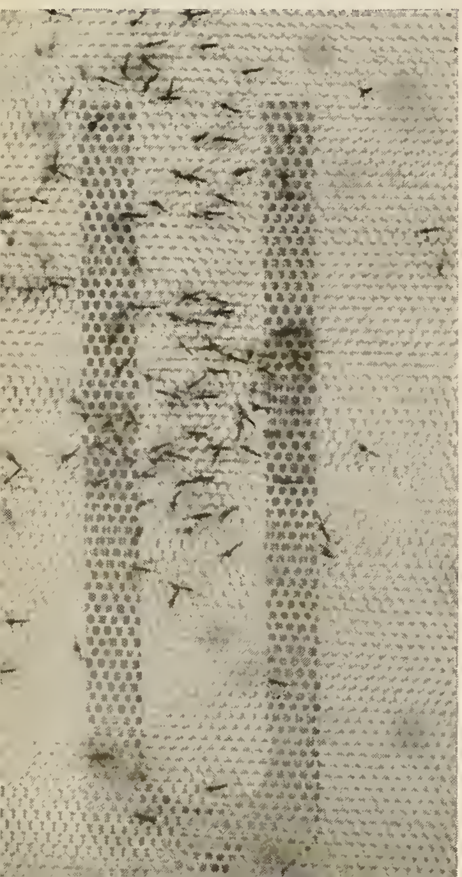
This peculiar phenomenon is remarkable in itself, although nothing is known about its significance. But one thing is clear. During the first forty-eight hours of his adult existence, the male has nothing to gain from an ability to hear the female. He would only expend valuable muscular energy in the fruitless pursuit of a sexual partner with which he could not mate. Interestingly, during this period the bristles on his antennae are not erect, as they are in older males, but lie recumbent against the antennal shaft (*see page 28*). Because the "amplifier system" is still non-functional, his chances of detecting the female are correspondingly low. This is a beautiful example of how two separate but interdependent events in the development of an animal—the revolution of the abdomen and the erection of the bristles—are synchronized to the obvious adaptive advantage of the animal as a whole.

Actually, a male newly emerged from the pupa hardly flies at all. This is attributable not only to his inability to mate but also, strangely enough, because in flight he would be attractive to older males. When a recently emerged male is forced to fly in a cage with older males, the latter pursue him and attempt to mate with him, and in the struggle the young male often loses some of his legs. A young male in flight has a wingbeat frequency close to that of the female, and the older males are simply drawn to him by mistake. Only when a male is mature do his wings assume a quicker beat, and the tone they then emit falls above the range normally attractive to other males. The discrepancy in the sounds emitted by mature males and females is, of course, the reason why sexual encounters between mosquitoes of the same sex do not ordinarily occur.

The female similarly remains at rest for some time after emergence. A young female, if forced to fly in a cage with males, is ignored. Her wings beat at a frequency that is still relatively low—too low, in fact, to attract males. Later on, the pace of her wings quickens and she becomes at-



Silent tuning fork, above, fails to lure males. Set into vibration, as below, it emits tone and attracts swarm of males.



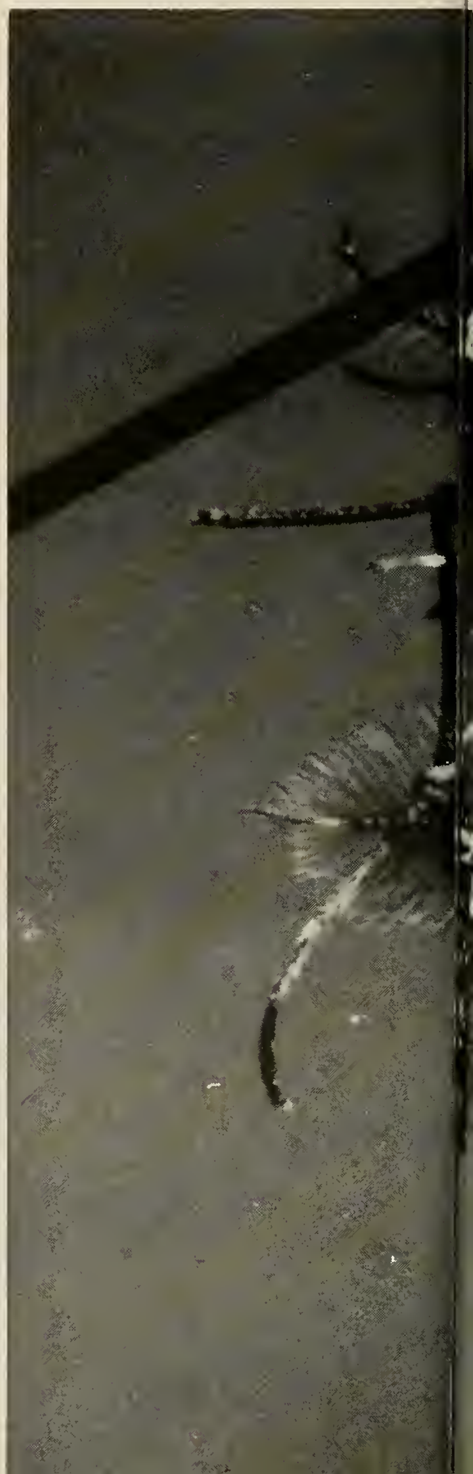
tractive. Thus, there are good adaptive reasons for the grounded existence that the two sexes favor just after emergence.

In its reproductive behavior, *Aëdes* is by no means unique, for there are many species in which mating is initiated in flight. But there are exceptions too. A most unusual one involves *Opifex fuscus*, a species recently investigated in New Zealand by J. S. Haeger and M. W. Provost. In *Opifex*, mating begins even before the female has fully emerged from the pupal skin.

The male *Opifex* habitually flies close to the surface of the water in search of pupae. His sense of sight is apparently well developed, for he orients rapidly to any ripples on the water created by the pupae when they surface for air. He may even detect movements below the surface. If a pupa comes within reach, the male seizes it with his forelegs and inserts into its back a pair of pointed prongs. Injury to the pupa is prevented because of the clearance that exists between the pupal skin and the body of the young adult inside. In the ensuing struggle, the pupal skin may rupture, and if the emerging adult is a female, the male clasps her genital apparatus with his own and completes copulation within minutes. Young pupae of *Opifex* minimize their exposure to males by surfacing only long enough and often enough to get the air they need. Still, the males sometimes make mistakes, even to the extent that they will occasionally pursue and capture pupae of the wrong species—a pointless endeavor.

Much attention has been given in recent years to insect behavior, and we now know a great deal about how males and females are brought together for mating. In many insects, sex attraction is accomplished by sound, as in *Aëdes*, but the sound is usually not that produced by the wings in flight. Special rasping devices and other sound-producing organs are commonplace, and one need only think of crickets (NATURAL HISTORY, November, 1966), grasshoppers, and cicadas to appreciate the diversity of species that have "mating calls." There are, of course, many "silent" insects that lure their mates by entirely different means. In diurnal forms, vision alone may suffice for sex recognition. Other species may rely on chemical sex attractants, produced as secretions by special glands. These sex attractants are the subject of intensive current research, since it is hoped that they might be usefully employed for insect control. It is conceivable, for example, that insects might be lured to traps that are baited with the insect's own sex attractants.

Exploratory efforts have also been made to control insects by the use of sound. As early as 1902, two British entomologists suggested that the knowledge gained from a study of the



effects of sound on various mosquitoes might be put to practical use. In the late forties, in Cuba, the sounds of a malaria transmitter, *Anopheles albimanus*, were recorded, amplified, and played back in the field. Males were attracted in huge numbers and killed on an electrified grid placed near the speaker. Although this approach proved impractical for large-scale programs of mosquito control, the possibility cannot be dismissed that sound might some day be used as an effective means of controlling other harmful or destructive insects.

Below, having been attracted by sound of wings, male mates with female glued to wire. Above, males of genus Opifex *pursue a pupa (object below mosquito at left). In this genus, mating can begin before female emerges from pupal skin.*

The British consul general, A. G. R. Rouse, walked into Manhattan's Kennedy Galleries for the opening precisely at five thirty, as promised. The paintings, thirty-four in all, had survived the rigors of shipment from England and now hung on the Galleries' putty-colored, non-declamatory walls. Carl Buchheister, President of the National Audubon Society, had arrived five minutes before the consul general. The two—honorary cosponsors of the exhibit—chatted amicably and were soon joined by gallery president Rudolf Wunderlich and the painter Basil Ede.

When all the guests had arrived, the consul general, in a brief, dignified speech, outlined Ede's career: school in Surrey; a stint as purser for Orient Steamship Lines; exhibitions in England and, in 1964, at the Smithsonian. Mr. Buchheister spoke next and commented on the influ-

Basil Ede's Birds In a New York Gallery

ential role of bird artists in wildlife preservation. He mentioned Audubon and Fuertes. A ripple of applause ended the formal part of the opening. Clusters of people then walked from painting to painting. Afterward, they drifted gradually out the front door on East 56th Street and into an overcast April evening.

Basil Ede once protested that some people appreciated only technical skill and did not grasp his principal aim—to convey the character of the subject. In Ede's case, it is difficult to avoid dwelling on craftsmanship. His technique is brilliant. Every detail of the Yellow-shafted Flicker, for example, is meticulously done: the horny sheath of the bill, the scutellate tarsi, the claws, and, notably, the elegant black moustache. Even the rictal bristles —tactile hairs at the base of the bill—can be counted and correlated with reality. Except for the recessive background and the startling pose, the painting of the flicker engenders the irrepressible impulse to test for verity, to view it from as near as possible.

Yellow-shafted Flicker

Colaptes auratus

Tree Swallow *Iridoprocne bicolor*

Baltimore Oriole *Icterus galbula*

This is also true of the Tree Swallows, particularly the one flying to the nest. Its wings are so lifelike that someone could be forgiven the plan to subject the painting to scrutiny under a microscope. That plan would make certain that artistic illusion is, after all, illusion and that—say in the swallow's primary wing feathers—Ede has not gone so far as to paint microscopic barbules. These tiny hooking devices, in the feathers of a real bird, interlock the barbs, the "feathery" parallel filaments that extend obliquely from two sides of the feather's main shaft. The barbs play a large role in producing the blue color of birds. Blue in feathers, as well as green and iridescence, results from structural coloration: the barbs are so built that all light but blue is absorbed by a pigment deep in the internal structure of the barb. Blue light is intercepted, so to speak, and reflected by a thin layer of cells closer to the barb's surface.

White feathers, as in the telltale rump of the flicker or in the equally distinctive undersides of the Tree Swallow, have no pigment. They reflect all wavelengths in the visible spectrum. Chemical substances govern color where structural, physical properties do not. These substances are actually pigments or, as they are called, biochromes, that absorb and reflect only specific wavelengths of the visible spectrum. The yellow of the flicker, the orange of the Bal-

timore Oriole, and the orange-red breast of the Robin are produced by carotenoids—technically the same pigments that color the fall leaves of the birch tree shown here supporting an abundance of Black-capped Chickadees. Their caps—to complete the gamut of color—like the dull, gray-brown topsides of the robins, are colored by melanins: granular, murky pigments that absorb anywhere from relatively many to virtually all wavelengths.

Two years before his death in A.D. 1250, Frederick II, a versatile Hohenstaufen who reigned as Holy Roman emperor, published a book on the art of falconry that, for its time, was ornithologically far advanced. One of the elements that made *De arte venandi cum avibus* a landmark was an accurate description of the uropygial, or preen, gland. Located on the rump, the uropygial gland, when

Black-capped Chickadee *Parus atricapillus*

Robin *Turdus migratorius*

squeezed or stimulated by the bill, secretes an oil reputedly rich in vitamin D. Certain feathers—and the process must vary widely by species—are then drawn through the mandibles, oil being thus transferred to the feathers. The oil presumably conditions or waterproofs, and the action of the mandibles, apart from spreading the oil, smoothes and re-engages the barbules. Even a bird that is a long time away from its last molt can, by continuous and vigorous preening, retain a modicum of sartorial elegance. The Belted Kingfisher at right, however, looks slightly unpreened. Its charm results, then, as much from the condition of its feathers as from its interest in the oxygenating fishlet. The

Belted Kingfisher *Megaceryle alcyon*

Canada Jay *Perisoreus canadensis*

kingfisher, it must be said, like the Pileated Woodpecker, shows more a condition of neglect than the careful and good grooming typical of most birds in the wild. But as Basil Ede warned, some people don't get beyond technique, and lest feathers alone obtain overriding significance, consider the Canada Jay.

This jay has been treated badly in the reports of at least several generations of northern woodsmen. In the *Life Histories,* for example, A. C. Bent quotes part of a letter written in 1895 by a certain Manly Hardy: "The Canada jay is almost omnivorous; it . . . will eat anything from soap to plug tobacco, for it will, at least, steal and carry off such unsavory morsels; some Indians have said: 'Him eat moccasins, fur cap, matches, anytink.' " In spite of the aspersions traditionally cast on its character, the Canada Jay enjoyed great popularity at the exhibition. Not only was it most frequently visited, but it also had the substantial distinction of being the first painting sold.

In contrast to the well-lighted, coniferous background accorded the jay, the combination of lichen and leafless trees gives the Pileated Woodpecker painting a less cheery, but far stronger, tone. In addition, it brings to mind again how magnificent a woodworking machine the woodpecker actually is: the powerful, elongated neck; the large, heavy skull;

Pileated Woodpecker *Dryocopus pileatus*

Great Horned Owl *Bubo virginianus*

and the chisel-ended bill that evidently drives into wood from two alternating angles—the way an ax is put to a tree by a lumberjack. Zygodactyl feet (each foot with two toes pointed forward, two pointed to the rear) and the stiff tail feathers form the functional tripod that supports the hammering bird.

In addition to acute hearing—with which the ear tufts, or "horns," of the Great Horned Owl have nothing whatever to do—and the soft plumage that muffles the prey-warning rustle of flight, owls possess perhaps the single most obvious adaptation for a life of nocturnal predation—extraordinary dim-light vision. That Basil Ede has painted the wide, yellow eyes so impressively is exactly fitting. His owl, properly, is all eyes, quietly colored feathers, and raptorial claws. At night a real owl gathers light and collects sounds and, so armed with information, locates, approaches, and seizes its prey. Those abilities and those consequences are suggested by Basil Ede's handsome and intent horned owl.

An Argentinean ornithologist who recently visited the Ornithology Department at The American Museum saw color photographs of Basil Ede's paintings. The ornithologist revealed that he was also something of a bird painter, although he confessed that his water colors were painted largely to illustrate taxonomic color patterns for a book on South American birds. Originally a Scandinavian, he spoke knowledgeably about European art, often mentioning Van der Meer. His comments on the Ede paintings dealt, in addition to ornithological considerations, with the subtleties of light and shadow. "One thing is certain," the Argentinean concluded, "Basil Ede is a master." *Alfred Meyer*

Photographs by Lee Boltin

Jungle Gods of San Agustín

Deep in the Colombian Andes, a bewildering array of monumental stone sculptures stands witness to a remote past. Now the site of an archeological park, this complex is not only a major tourist attraction but also a subject of continuing speculation and research.

by G. Reichel-Dolmatoff

In 1757 a Spanish friar, Juan de Santa Gertrudis, was laboriously crossing the lonely fastnesses of the Andes, on his return from a mission station on the headwaters of the Amazon. One day, followed by his Indian carriers, he arrived at a small cluster of huts, the village of San Agustín, situated on the very source of the Magdalena River, deep in the mountain folds of the mighty Andean core. From here, the three great chains of the Colombian cordilleras spread toward the north.

The village had few people to welcome the lonely traveler, but among them happened to be another cleric, a member of the Third Order, who had established himself at San Agustín on a special mission and who now cheerfully offered his hospitality to the tired priest. Over a hearty evening meal the cleric confided to Friar Juan that he was an inveterate treasure hunter, and that, with the help of laborers he had brought with him from the city of Popayán, he now was digging for buried gold among the ruins and monuments—evidence of a long-forgotten race—he had found scattered in the surroundings of the village. The next morning, while his Indians were still asleep after a night of merrymaking, Friar Juan set out to see for himself, and soon was standing in awe before a strange assembly of huge sculptures hewn out of solid rock.

In a naïve account of his adventures, Friar Juan writes that what he then saw was clearly the work of the Devil. To the friar, the statues obviously represented mitered bishops in pontifical garb and also Franciscan friars of the Observant Order, some shown as if preaching, while others seemed to be standing in meditation with arms crossed and hands hidden in the wide sleeves of their clerical robes. But, Friar Juan reasoned, since these images must surely be older than the Order of St. Francis and the Indians did not possess iron tools for stone carving, only the Evil One himself could have fashioned these strange images, perhaps to forebode the coming of Christ's ministers to the American infidels.

This first description of the now famous archeological site of San Agustín remained unpublished for nearly two centuries. It was discovered only recently in the public library of Palma de Mallorca, Friar Juan's native town, where he died in 1799 after many years of travel and missionary work in the kingdom of New Granada, or what is today Colombia.

After Friar Juan, others had come, and with them the realization that the stone images ranged through many types not limited to those Friar Juan wrote about. In 1797 Francisco José de Caldas, Colombia's scientist-martyr of Independence times, visited San Agustín and, in his later writings, called public attention to the prehistoric monuments he found in the surroundings. In 1853-54 the Italian geographer General Agustín Codazzi mapped the region, remaining for some time in the village. To his companion, the painter Manuel María Paz, we owe the first pictorial record of some of the stone images.

More than half a century passed, however, before any systematic exploration was begun. It was only in 1913 that Konrad Theodor Preuss, of the Museum für Völkerkunde, Berlin, initiated scientific archeology in Colombia by making the first large-scale excavations at San Agustín. His profusely illustrated report first brought the stone sculptures of San Agustín to the attention of the scientific world; since then sporadic expeditions have come to the Magdalena headwaters in search of more statues and temples.

In 1935 the Colombian Ministry of Education put the main archeological remains under government protection and established an "archeological park" as a tourist attraction and a center for research and preservation. Major excavations were carried out in 1936-37 by the Spanish archeologist José Pérez de Barradas, and since then work by Colombian and foreign research teams has continued intermittently. However, not all of these excavations have met the more exacting standards of latter-day archeological theory and method. If Friar Juan was puzzled by what he took to be images of solemn priests and monks, the modern archeologist must admit that, even at present, many questions concerning the origins and wider relationships of San Agustín culture remain unanswered.

Today the old Andean village of San Agustín has developed into a small, but active, center of cattle raising and agriculture. Located on the eastern flanks of the Macizo Colombiano, the little town lies in a furrowed, fertile valley, at an altitude of about 5,500 feet above sea level. The local peasants, mostly descendants of immigrants from neighboring districts, take pride in the international fame their narrow valley has ac-

Stone images represent humans, animals, and monstrous combinations. The fanged human here indicates worship of jaguar god; a string ties penis to pelvis.

What the sculptures signify is usually conjectural. This huge triangular head stands at the foot of a temple mound in the archeological park at San Agustín.

quired for its prehistoric past and eagerly guide the visitor to the many monuments found in the surrounding hills and mountain slopes.

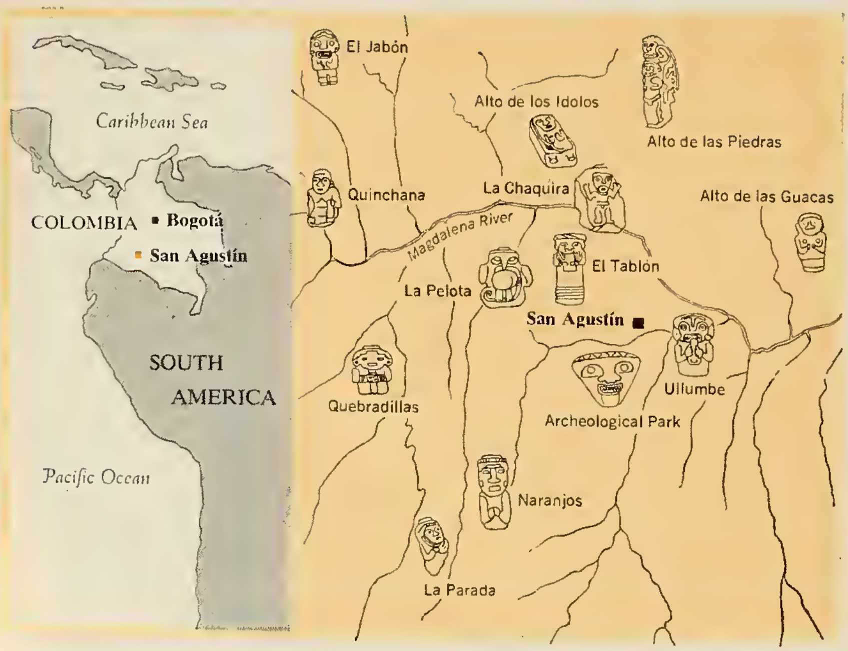
Actually, San Agustín is not a compact site, a single center, but rather a complex formed by thirty or more small, widely scattered units. Accordingly, the over-all archeological area covers several hundred square miles, and because much of the countryside is heavily forested, its exact limits are still unknown and new discoveries are frequent. At any rate, the outstanding traits of San Agustín culture are its architectural features and monumental carvings.

For raw materials the ancient builders certainly had not far to go: large boulders of andesite and basalt are common in the valley. These materials were built into many low, conical earthen mounds; some served as shrines, others were used for burial purposes and contained prepared central crypts or tombs reached through a stone-lined gallery. There are mounds that reach a diameter of almost one hundred feet and a total height of more than sixteen feet: these may contain several crypts. Construction is of rough blocks and boulders, some set like heavy columns and sustaining a roof of horizontal slabs. The heaped-up earth covering the structure is sometimes kept in place by a circular retaining wall of vertical slabs.

The central crypt generally has a rectangular ground plan, and the rough inner surfaces of these sepulchral chambers or shrines still bear traces of paint showing geometric designs in red, white, black, and yellow. Huge anthropomorphic stone carvings or large monolithic sarcophagi have been found in the mounds, where the spirits of the dead and the demonic representations of tribal gods were worshiped.

Either combined with these mound structures or standing apart, singly or in groups, are the large stone sculptures for which San Agustín has become justly famous. Nor are they only of the "bishops" and "monks" that intrigued Friar Juan. The great stylistic variety of these impressive statues (more than 320 are known today) makes it difficult to give a concise, over-all description of them. Some consist of huge slabs with bas-relief carvings on the flat front and back surfaces; others are simple cylindrical shapes on which a human or animal figure is outlined only superficially. Still others, carved in the round and using various planes, give proof of highly skilled workmanship and true mastery of form and material. Varying in body proportions and height—the tallest statues are about twelve feet—these stone carvings show a wide array of human and animal shapes or monstrous combinations of both.

Squat human bodies with short, stiff limbs carry disproportionally large heads with feline features. Pointed fangs protrude from snarling jaws. There are warriors with helmets and clubs, with secondary figures crouching on their heads, as if climbing over the backs of the statues. Others show females with elaborate headdresses, squatting animals, and a bird of prey holding in its beak and claws a writhing snake. But these stone carvings are not limited to free-standing statues of sculptured slabs; they are found also on



bedrock outcrops and on the huge boulders that dot the countryside. Some boulders with more or less flat surfaces are covered with reliefs of snakes, lizards, frogs, or human beings, which are chiseled or scratched into the volcanic rock. An extraordinary complex of intricate carvings can be seen at the Lavapatas site where bedrock exposed by a small stream has been sculptured in such fashion that a number of small, meandering ducts distribute the fast-flowing water into several pools whose walls are adorned with carved reptiles and human figures. Similar *in situ* carvings will most likely be found in other spots as the forest is cleared by advancing colonists.

Gods or divine ancestors, priests or warrior chieftains, whatever these strange statues and carvings were meant to portray, their stolid weight and fierceness of expression never fail to impress the onlooker and make him wonder who the people were whose inner vision projected these weird images in stone. No doubt the creators of these mounds, temples, and statues were sedentary agriculturalists—maize farmers who peopled the hilltops in scattered villages and homesteads. Large, rectangular grinding stones and loaf-shaped *manos* are found at many sites, and on some of the mountainsides one still can see the outlines of ancient fields. Long parallel ridges, separated by shallow furrows, cover the slopes and bear witness to fairly advanced agricultural techniques. Next to maize it is probable that squash and beans were cultivated, and these, together with the root crops and the many wild-growing fruits characteristic of Colombia's temperate mountain valleys, must have provided a stable economic basis.

No large village sites have yet been found at San Agustín, but several small clusters of circular houses have been excavated in recent years. Except for some stone alignments, it seems that domestic architecture employed wood instead of stone, and that the houses were constructed with

Many statues are elaborately designed guardians of the dead. Surmounting the helmeted head of this armed warrior is figure of a helpful tutelary deity.

mud-covered walls and had conical, thatched roofs. The pottery found in these house sites or in the graves and mounds is rather drab, and simple in shape and decoration. The monochrome brownish or reddish wares are mainly utilitarian vessels and bowls, shallow plates and dishes, pedestal cups, double-spouted vessels with spherical bodies, and some tripods with elongated conical supports. Decoration consists of rows of dots, incised geometric designs forming triangles or groups of parallel lines, and, occasionally, the reversal of pattern and background called negative painting. Even pottery associated with the burial sites is undistinguished, and the same is true of the stone celts, clay spindle whorls, or stone necklace beads found so far.

The apparent simplicity of the ceramics and other artifacts of daily use is in sharp contrast to all aspects of ceremonial character. However, San Agustín is not a temple center supported by a large community settled in the surroundings. Although there may have been specialized priests and artisans, the house sites found so far suggest a widely spread rural population, similar in many details to maize farmers in many other Colombian valleys. And the ceremonial features—mounds, shrines, monumental sculptures, and so on—are not centered upon a major architectural complex but mostly seem isolated traits whose common basis is emphasis on burial rites and representation of tribal deities.

The range of burial customs is wide: stone-lined cist graves, monolithic sarcophagi, shaft graves with vaulted lateral chambers, clay burial urns, even incineration. The position of the corpse varies accordingly. In some graves the dead are buried in a flexed position; in others they lie fully extended or even stand upright in the grave shaft. This marked variety of customs has sometimes been interpreted as indicating a social stratification, but it seems more reasonable to suppose that the main differences in burial rites reflect different chronological phases.

The large, monolithic sarcophagi, sculptured out of a single rock weighing tons and sometimes provided with carved lids and conical projections for carrying, are certainly an outstanding feature. They may well have served for the burial of chiefs or priests, but the many types of cist and shaft graves, urn burials, or simple pits are probably due to changes in time. In some of the graves a few gold objects have been found, but the art of metallurgy, for which other regions of prehistoric Colombia are famous, does not seem to have flourished at San Agustín. A few flat nose rings, ear ornaments of thin wire, and some small bird-shaped pendants have been found, but little is known about their associations and techniques. Although the lost-wax method (*see* NATURAL HISTORY, August-September, 1965) seems to have been known to the local goldsmiths, its use never reached the level of perfection we can see in other prehistoric cultures of Colombia.

This returns us to the stone carvings, because many statues display a great number of body ornaments and other features permitting a glimpse at some aspects of the material culture of these people. Some statues wear nose rings—chiseled into the stone—of the same flat, wing-shaped type as those found among the golden hoards of the Central Cordillera farther north. Other ornaments depicted on stone may also have been of gold; for example, a variety of bracelets, ear ornaments, or diadems. However, many of the sculptured necklaces that adorn the statues probably represent ancient strings of stone or shell beads.

Female dress, judging by the stone sculptures, was limited to a wraparound skirt or a small square apron, the latter also a common part of male clothing. Some male statues, however, are nude except for a string to which the penis is tied. There is a strong emphasis on elaborate headwear, from small round caps to tasseled hats, helmet-shaped objects, or large semicircular ornaments that most likely represent feather crowns. Many statues carry objects in their

Some of the images are highly stylized. This large slab portrays a figure who is grasping a pair of staffs—another widespread motif in Andean archeology.

Along with tribal gods, spirits of the dead are part of sculpture array. This crypt is roofed with stone; the other slabs serve as earth-retaining walls.

hands, either clutched to their chests or displayed menacingly. One seems to play a flute; another carries a fish; still another holds a snake. A female statue has a cup in one hand, and some of the male statues seem to carry shields. A skull trophy adorns yet another statue, and others appear to be wearing masks or holding staffs in their hands.

The over-all impression of these carvings is one of bewildering diversity of technique, style, and detail of representation. Some statues show hardly more than the bare outline of a body—a crouching figure not yet extricated from the heavy boulder—but others are true free-standing sculptures, fully individualized and sometimes in powerful movement. Hundreds of battered stone celts, found at the foot of some of these sculptures, were tools with which the native artists shaped the images.

The symbolism of the statues, and of the many subsidiary carvings covering some of them, has aroused much speculation. A recurrent theme is the beastlike snout, reminiscent of a snarling jaguar with protruding fangs. Although the rest of the body is essentially of human shape, the ferocious features of the jaguar-monster are very prominent. Probably, these statues represent the feline god widely worshiped in ancient America.

More difficult to interpret are the representations of another monstrous deity. It seems to be tearing from its mouth a small being that hangs, head down, as if half swallowed or half brought to light. Again, it would not be difficult to find parallels with other prehistoric cultures, ranging from Nazca in Peru to Costa Rican stone carvings, but the meaning of this motif is unknown. Preuss saw in this representation a solar deity consuming a child sacrifice—an interpretation shared by several Colombian scholars. Other statues have been variously interpreted as rain gods, war gods, bat gods, lunar deities, and so on, but obviously the evidence for all this is tenuous.

Striking, too, are the statues with a "double," an alter ego, crouching on their backs. The idea has been

Locally called "El Buho," this carving depicts an owl-like hawk with serpent in its beak and claws—a symbolic motif often found in Colombian mythology.

advanced that the secondary figures represent tutelary spirits that hover over warriors, but more likely the concept is derived from animal furs being carried on the back. This supposes the animal head is meant to form a mask, perhaps a special type for ceremonial purposes.

One of the best-known stone carvings shows a large bird, an "owl," holding a snake in its beak and claws. Probably this statue represents a Crane-Hawk (*Geranospiza caerulescens*), a bird common in the tropical lowlands of Colombia and often seen catching snakes this way. The hawk-and-snake dualism, with its East–West association of life-bringing and life-destroying forces, is a frequent motif in the myths of the modern Indians of northern Colombia, and it may well be that the San Agustín sculpture shares this symbolism.

However tempting these comparisons and interpretations may be, they are hardly more than guesswork, and we need firmer ground if we want to trace the growth and external relationships of local culture. First, because of San Agustín's undoubtedly long history, comparisons must be established on different levels. One cannot speak of a "San Agustín style"; the variety of stone carvings, of burial customs, and of pottery types all indicate that the passage of time brought these differences.

In the second place, the diffusion of San Agustín culture and its different phases within Colombia has not yet been traced in adequate detail, especially with reference to the correlation of ceramic types from other regions. The oldest radiocarbon reading obtained so far is 555 B.C. This date, according to Luis Duque Gómez, the foremost Colombian authority on the subject, marks the beginning of the so-called Lower Mesitas Period of San Agustín, the end of which would be marked by the date A.D. 425. It is within this time span of almost a thousand years that Professor Duque has placed the following traits found at San Agustín: the shaft graves with lateral chambers; the predominantly monochrome pottery in the shape of globular jars; the pedestal cups, dishes, double-spouted vessels, and tripod vessels; the frequency of incised decoration, but occasional occurrence of bichrome and negative paint; the beginnings of metallurgy; and the cultivation of maize. The next period (Middle Mesitas), postulated between A.D. 425 and 1180, is characterized by monolithic sarcophagi; the construction of large burial mounds; stone-cist graves and urn burials; and the development of stone carvings. With a few exceptions the same pottery tradition continued, but the metallurgy of gold now contained some new techniques in pottery decoration, such as crosshatched incisions and tubular stamping.

This sequence, covering the better part of two millenniums, is, of course, not more than the barest outline of cultural developments; future research will aim to break down these periods into smaller units. However, the present postulate can serve as a tentative basis for discussion. First, 555 B.C. probably does not mark an initial stage of the local culture. Placed within the wider context of development in Nuclear America—the region extending from central Mexico to northern Chile where ancient cultures were most advanced—such traits as large anthropomorphic statues, the feline cult, head trophies, perhaps also monolithic sarcophagi are probably much older, and if we can assume a genetic relationship between the Olmec culture of Mexico and the Chavín culture of Peru, would precede the San Agustín date by several centuries.

As current research probes deeper into contacts between Mexico and the west coast of South America, it becomes increasingly likely that the San Agustín area and, perhaps, other regions of inter-Andean Colombia received a strong stimulus from groups that might have penetrated from the Pacific coast toward the Cauca and Magdalena valleys. Such movements, although basically coastwise, probably led to diffusion along these valleys and the Andean spine. At any rate, recent archeological research on the Pacific coast of Colombia has brought to light new evidence of overseas contact with Mexico about 500 B.C. It is significant that some pottery types from the coastal regions seem closely related to the ceramics of San Agustín, especially those of the Lower Mesitas Period, and it is probable that future research will be able to establish definite links between the seafaring Mesoamerican colonists and the inter-Andean maize farmers of Colombia. But again, the deeper roots of San Agustín must go back to a still earlier time level, the one during which the cult of the jaguar god was diffused. A tentative date of about 1000 B.C.—correlating the Olmec and Chavín cultural periods—would mark this horizon. Its identification and characteristics are at present one of the main tasks of American archeology.

Although the adjectives most frequently applied to San Agustín culture are "mysterious" and "enigmatic," it is obvious to the archeologist that there is nothing that could not be resolved by future field work. Careful stratigraphic excavations, sherd analyses, and the working out of pottery sequences may be tedious and unspectacular tasks, but they are the only valid and rewarding methods we can use to place San Agustín and its ancient creators into the wider context of American prehistory.

Another example of fierce countenance with jaguar teeth, this monument at San Agustín portrays a god holding a small child, perhaps a victim for sacrifice.

SKY REPORTER

Do comets really break down to produce meteor showers? Radio astronomy's methods of observation provide valuable new data

By Thomas D. Nicholson

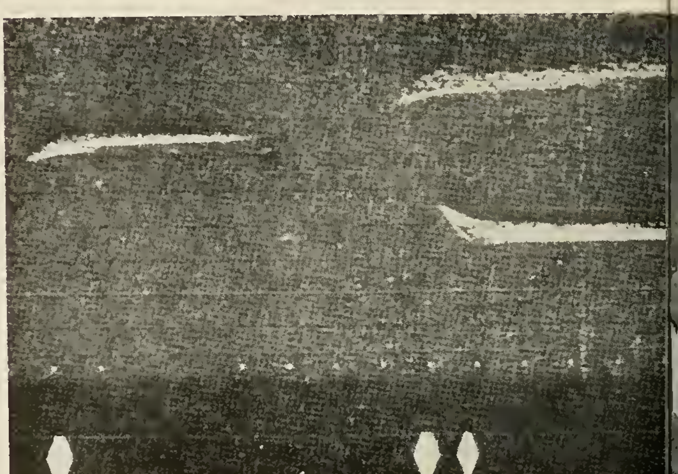
After about a century of wandering unseen through the solar system, Comet Tempel-Tuttle was detected last year in a search conducted by the German astronomer Dr. J. Schubart. Originally discovered independently by W. Tempel of France in 1865 and H. P. Tuttle of the United States in 1866, the faint comet had returned twice—in 1899 and in 1932—but was not seen either time. Schubart was using Comet Tempel-Tuttle to test a special computerized program for predicting the positions of objects orbiting in the solar system.

This comet's main importance is the similarity of its orbit to the orbit of the meteor stream responsible for the famous November shower, the Leonids. Giovanni Schiaparelli, in 1866, first pointed out the apparent relationship between comets and some of the annual meteor showers seen by man. Since Schiaparelli's time we have developed new visual, photographic, and radio techniques for observing meteors: methods that enable easy and accurate calculations for the orbits of meteors and the swarms of particles that produce meteor showers. Most useful are the radar techniques, which permit direct measurement of meteor positions, paths, and velocities from a single station. Generally, radio has made meteor observations somewhat independent of weather and has extended this work into daytime hours.

Radio methods depend upon the fact that meteor trails reflect radio waves. The solid meteoroid itself, the particle that produces the meteor, is not actually observed. But the meteoroid particle, as it travels through the earth's atmosphere, leaves in its wake a column of ionized gases. It is this trail of charged gas particles, persisting briefly after the meteoroid has passed, that is detectable by a reflection or echo of precisely timed pulses of radio energy, which are beamed toward the sky. The characteristics of this radar echo reveal the presence of a meteor, its distance from the ground station, and the velocity of the meteoroid particle.

One of the most exciting results of radio meteor observations was the discovery of meteor showers that occurred during daylight hours. From early May until late July, the earth apparently encounters a broad, complex series of meteor streams approaching from the sunward side and, therefore, producing daytime meteors. Sir Bernard Lovell of the University of Manchester, England, identified about twelve distinct radiants in this late spring and early summer display, although only three of them are sufficiently abundant and reliable to be classed as major showers. Among these is one, the daytime Arietids, that turns out to be the most active annual shower of the year, even more so than the two most active annual nighttime showers, the August Perseids and the December Geminids.

Another daytime shower, the Beta Taurids, fulfilled an interesting prediction made in 1940 by Professor Fred Whipple of Harvard. He calculated that the low-yield autumn Taurid shower was in reality a major stream of particles dispersed over a long column of space, deducing this because the earth took from mid-September to mid-December each year to pass through it. He also calculated that the stream revolved around the sun in a period of about three and a half years in almost the same plane as the earth's orbit. He concluded that the stream should return to the earth's orbit again, after passing around the sun, in late June and early July, but this time approaching in the daytime sky. Radio discovery of the Beta Taurid shower, reaching maxi-



Radar echoes of three bright meteors (top) give their velocity and distance; marks below confirm time of visual sighting. At right is photo of all-sky, visual observatory.

Halley's Comet is associated with two streams of meteors, although orbits differ somewhat. Photograph of this famed visitor was taken in 1910, the comet's most recent sighting.

mum about June 29 each year, confirmed the prediction.

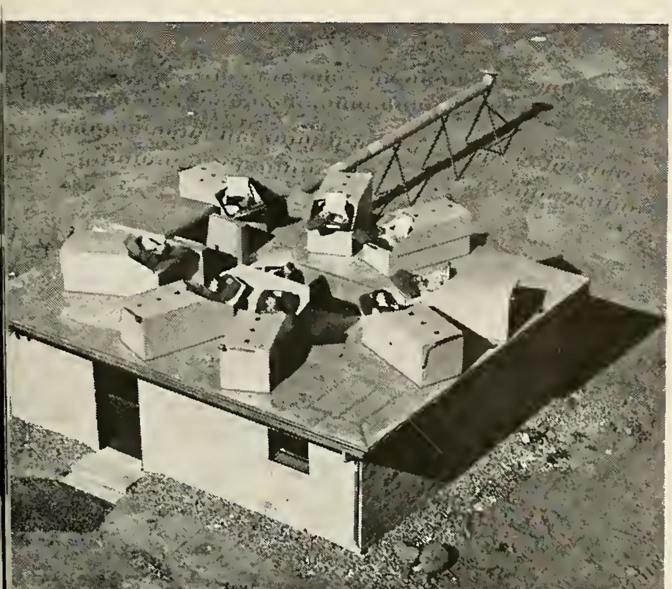
With the addition of the three major daytime showers discovered by radio, and the inclusion of two showers of recent discovery (the Phoenicids and Ursids), plus two periodic showers (the Geminids and Leonids) and two lost showers (those observed annually for some years and then seen no more, as in the cases of the Bielids and the Pons-Winnecke shower), the number of known major meteor showers may now be placed at seventeen. The characteristics of these showers are summarized in the table on page 52. Many minor showers of low activity and somewhat doubtful regularity have been excluded from the table. Some authors prefer to separate some of the showers in the table into two or more, each representing what may possibly be subradiants within one broad mainstream. Thus, the Delta Aquarids and the November Taurids are sometimes separated into southern and northern components.

Since the early work of Schiaparelli and his contemporaries in relating the orbits of the Lyrids, the Perseids, and the Leonids to the orbits of known comets, ten of the major meteor showers have been found to follow orbits closely similar to the orbits of comets. Such associations also have been found between comets and the orbits of a few minor streams or some of the subradiants of broad streams, but not all these associations are positive, because the orbits of the comets and the meteor streams, although similar in many ways, depart significantly in others. For example, in the association between Halley's Comet and the Eta Aquarids and the Orionids, the periods and inclinations of the meteor streams are quite different from those of the comet.

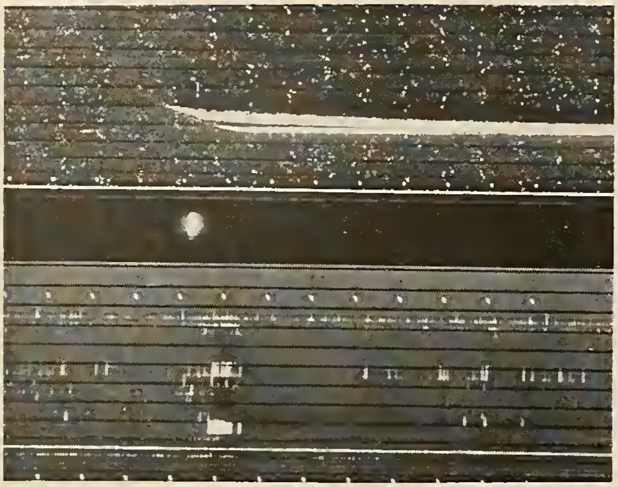
In many of the associations between comets and meteor showers, however, the orbits are similar enough to suggest that the two are physically related. One possibility is that the meteor swarm is primeval matter out of which the comet was later formed. Another is that meteoric material has been ejected from, or left behind by, the comet in the process of its disintegration.

There are several arguments in favor of the possibility that a meteor stream is the debris left behind by a comet as it moves in its orbit around the sun. Present-day cometary research supports the view that comets must slowly disintegrate as they pass through the solar system, losing some of their material each time they move around the sun. Several comets have actually been observed to disintegrate. An outstanding example is Biela's Comet. A major shower, over several hundred meteors per hour, occurred repeatedly after the breakup of the comet, at intervals coinciding with the period of the comet.

Although these arguments favor a cometary–debris hypothesis over one of common origin for comets and



Rapid track of a bright Perseid meteor, broken by shutter to measure velocity. The dimmer, curved trails show slower movement of stars as they revolve around celestial pole.



A Geminid meteor was observed in three ways. Top, radar made this track. Center, observer pressed button to give white time marker. Bottom, photocell showed brightness.

their associated meteor streams, they do not prove that a physical relationship actually exists. The only proof is the close association between the orbits of some meteor showers and certain comets. And the following factors seem to argue against the possibility that meteor showers are caused by cometary debris.

First, there are several major meteor showers for which no cometary associations have been found. This could be explained by the possibility that the comets once responsible for these meteor streams may have disintegrated in the past, except that some meteor stream orbits are so different from any known comet orbit that this possibility, seemingly, is ruled out. The meteor streams that produce the Quadrantids, the Delta Aquarids, the Geminids, and the daytime Arietids, for example, are in orbit around the sun in periods of two years or less. But among all known comets there are only six with periods of revolution around the sun of less than five years, the shortest periods being 3.3 years for Encke's Comet and 2.3 years for Comet Wilson-Harrington (observed only once). It would seem difficult to account for these short-period meteor streams on the basis of cometary origin.

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Perhaps an even stronger argument against the cometary origin for meteor streams lies in the large number of observed comets that apparently have not produced a meteor shower. J. G. Porter of England has identified sixty-eight comets with orbits approaching the earth close enough to produce meteor showers, although no showers can be associated with them. He further identified nineteen periodic comets that have come within 0.1 astronomical units (about 9,300,000 miles) of the earth's orbit, but only one probable and six certain associations have been found between these comets and major meteor showers. The apparent absence of meteor showers associated with so many comets having suitable orbits would suggest that astronomers be cautious in accepting meteor streams as being cometary debris.

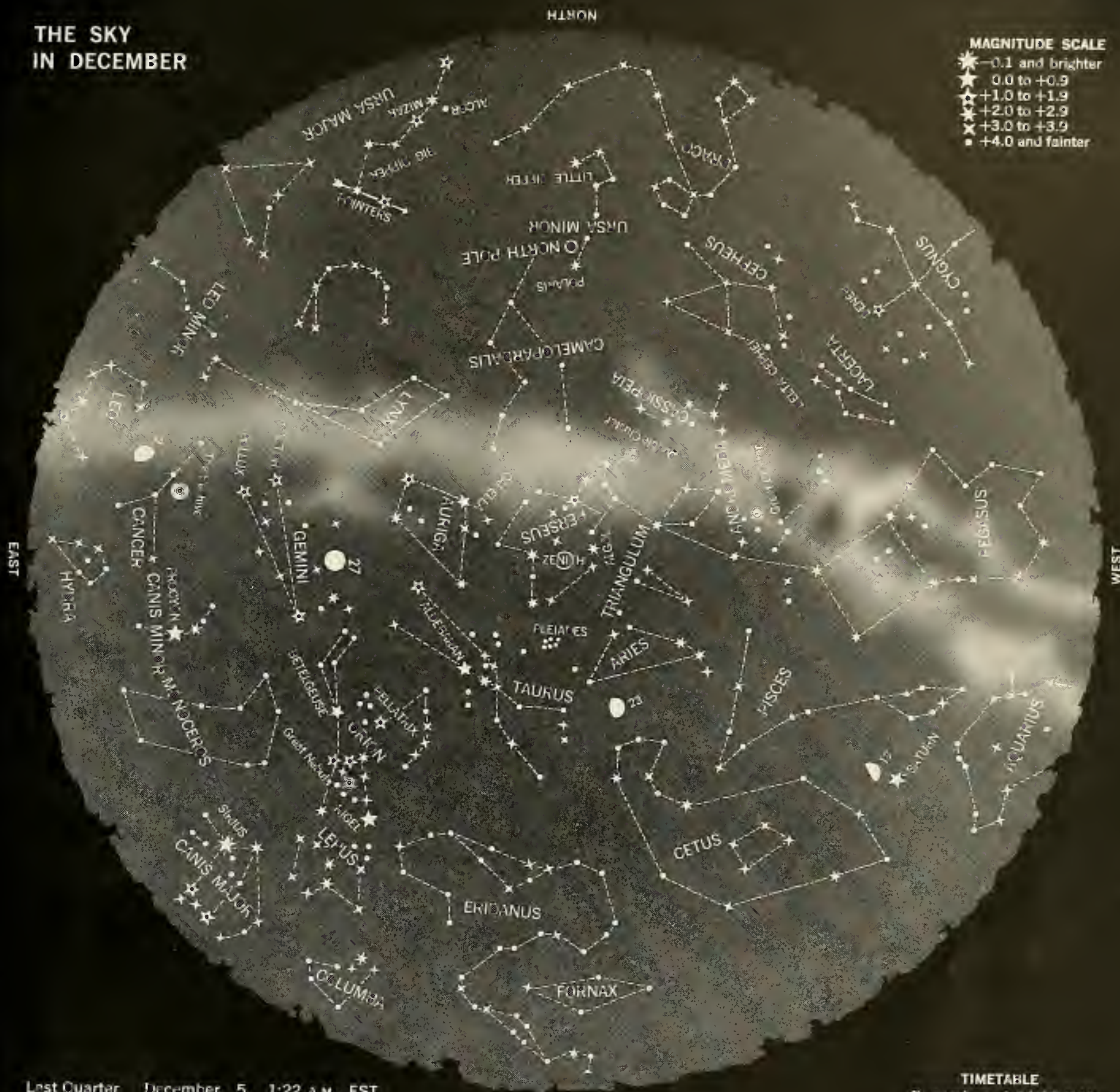
However, nothing in the above arguments disproves the possibility that meteor streams are produced by comets. There is an obvious relationship of some kind between comets and many of our major annual and periodic meteor showers. This has stimulated some astronomers, notably Professor Whipple, to investigate the processes that could disrupt a comet, produce a stream of particles in its orbit, and spread the particles into the kinds of meteor streams that we observe today. Whipple pictures a comet as a conglomerate of gaseous ices and particles of stony and metallic dust frozen into a slush. Each time such a comet approaches the sun, the heat of solar radiation vaporizes its outer layers, but not the non-volatile dust particles. These are blown away by the pressure of solar radiation or corpuscular streams —the solar wind—to form a meteor stream. The pressure of sublimating gases also ejects particles, more violently as the comet approaches closer to the sun. In these and other processes, Whipple is able to account, in theory, for most of the features we observe in meteor streams on the basis of cometary origin. But the last word has not been heard on this interesting subject.

MAJOR METEOR SHOWERS

Shower	Date of Maximum	Duration (days) of Peak Activity*	Hourly Rate**	Remarks
Quadrantids	January 3	0.5	50	Appears annually.
Lyrids	April 21	2	10	Appears annually. Associated with Comet 1861 I.
Eta Aquarids	May 4-6	18	20	Appears annually. Possible association with Halley's Comet.
Arietids	June 7	20	60	Appears annually; daytime.
Zeta Perseids	June 9	15	40	Appears annually; daytime.
Pons-Winnecke	June 28	0.25	100	Lost. Associated with Comet Pons-Winnecke.
Beta Taurids	June 29	10	20	Appears annually; daytime. Associated with Encke's Comet.
Delta Aquarids	July 28	20	20	Appears annually.
Perseids	August 12	5	50	Appears annually. Associated with Comet 1862 III.
Giacobinids	October 10	0.10	>100	Periodic. Associated with Comet Giacobini-Zinner (1946 V).
Orionids	October 21	8	20	Appears annually. Possibly associated with Halley's Comet.
Taurids	November 3-10	30	10	Appears annually. Associated with Encke's Comet.
Leonids	November 16	4	15	Periodic. Associated with Comet Tempel-Tuttle (1866 I).
Bielids	November-December	0.25	>100	Lost. Associated with Biela's Comet (1852 III).
Phoenicids	December 5	0.5	50	Newly discovered (1956), possibly periodic.
Geminids	December 13	6	50	Appears annually.
Ursids	December 22	2	15	Appears annually. Discovered in 1945. Associated with Comet Tuttle (1939 X).

*In which activity is one-fourth or more of rate at maximum **Average for a single observer looking toward the zenith

THE SKY IN DECEMBER



Last Quarter	December 5, 1:22 A.M., EST
New Moon	December 11, 10:13 P.M., EST
First Quarter	December 19, 4:41 P.M., EST
Full Moon	December 27, 12:43 P.M., EST

TIMETABLE

December 1	11:00 P.M.
December 15	10:00 P.M.
December 31	9:00 P.M.

(Local Mean Time)

December 1-10: Mercury, low in the east-southeast, reaches greatest westerly elongation on the 4th, when it rises about an hour and forty minutes before the sun. It appears, at magnitude zero or brighter, to the left and below the brightest star (Alpha) in Libra, and moves progressively farther left of the star each morning.

December 2: Jupiter and the waning gibbous moon are high in the western sky at dawn, Jupiter to the left and below. Conjunction is at 5:00 A.M., EST.

December 6: The crescent moon is high in the south-southeast at dawn, and Mars, about magnitude +1.3, is just below it. Conjunction is at 8:00 A.M., EST.

December 10: Mercury, now fainter and lower in the morning sky, rises just after the late crescent moon. Conjunction is at 11:00 A.M., EST.

December 12-14: The Geminid meteors reach maximum on the 13th and are best observed well up in the east during late night and early morning. This shower is reliable and productive, yielding at maximum an average hourly single observer rate of approximately 50 meteors, appearing to emanate from a point near the bright star Castor in Gemini.

December 17: The earth passes through the plane of Saturn's rings for the third and last time during this year's sequence, and for the next 13.7 years we will look at the sunlit southern face of the rings.

December 18-19: Saturn is in conjunction with the moon at 7:00 A.M., EST, on the 19th.

December 22: The winter solstice occurs at 2:29 A.M., EST, when winter begins in the Northern Hemisphere.

The rather weak Ursid meteor shower, producing about 15 meteors per hour, reaches maximum.

December 29: Jupiter and the moon again are high in the western sky at dawn. Conjunction is at 9:00 A.M., EST.

All month: Only Saturn, magnitude +1.3, is visible in early evening, to the south among the faint stars of Pisces, from dusk until it sets about midnight. Jupiter and Mars rise during the night and remain in the sky until dawn. Mercury is a morning star for the first third of the month. Venus, although an evening star, is too close to the sun to be seen, and sets within a half hour of sunset.

Tree of Light

by Harold Gilliam   photographs by Michael Bry

In San Francisco the sunlight reflects upward from the mirror of the bay to the hills; it gleams from the roaring white surf along the ocean boundary; it glares from the surface of fogbanks rolling through the Golden Gate and over the coastal hills; and it reflects in subtle shades from the leaves of the great eucalyptus trees in Golden Gate Park, in the Presidio, and in Sutro Forest. In this relatively treeless community, the eucalyptus is the chief arboreal presence, and the effect of sunlight on it is a distinctive aspect of the city.

The special muted quality of this light is partly the result of the arrangement of the leaves. They are more widely spaced than those of the poplars and of other trees whose leaves are often so dense that the observer sees only a wall of vegetation.

Look upward from a point near the base of a 150-foot eucalyptus and you see terrace after terrace of foliage, each with its clusters of leaves shimmering with a different vibration as they are stirred by any slight movement of air. It is as if your eye were moving upward from the base of a Gothic tower as the sunlight illuminated, one after another, successive rising arches and buttresses, spandrels and spires. In truth, each of these trees is a distinctive example of natural architecture, with its own variations of the principles of visual rhythm, balance, and proportion. No man-made towers display more variety and ingenuity of design.

It might be more appropriate, however, to compare the eucalyptus with contemporary rather than Gothic architecture. In keeping with the principles of modern architecture developed by Maybeck and Wright, the structural members—trunk and limbs—are largely visible and an essential part of the total visual effect. Unlike buildings and trees that hide their inner structure behind curtain walls or curtains of foliage, the eucalyptus has limbs that usually leave the trunk at an angle and sweep leaflessly upward in long, arching lines before dividing into smaller, leaf-bearing branches. The trunk and branches reach upward and outward in a flowing motion climaxed by spreading masses of lacy foliage, each shining with reflected sunlight.

The quality of the light associated with these trees also is a result of the leaf attachment. The leaves of most other trees extend stiffly outward from the branches, reaching for the sunlight, but in most species of eucalyptus the leaves—long, narrow, and curving like a scimitar—hang straight down. They move freely and separately in the breeze, suspended like Japanese wind chimes, resulting in a shimmering effect over the entire tree.

Visitors to the city are often surprised to learn that the eucalyptus is not a native of either this region or this hemisphere. It is difficult to imagine San Francisco—or California—without these trees, but where today the tall groves stand, the arriving Americans saw nothing but dunes, treeless hillsides, and open fields.

During the early 1850's, with ships beginning to arrive regularly from Australia, it was inevitable that one of them would carry some of the aromatic seeds of that continent's most abundant tree. Some may have

Foliage of San Francisco's eucalyptus trees catches both sunlight and fog for unusual light effect.

been planted here as early as 1850, but the first large plantings on record were made about 1856 by nurseryman William C. Walker in his Golden Gate Nursery at Fourth and Folsom Streets in San Francisco.

The promoter's name has been lost to history, but the "eucalyptus rush" began half a century after the gold rush. The word got around quickly; beginning about 1904 the news began to spread that the eucalyptus was exactly the tree to put an end to the United States "hardwood famine." The eucalyptus was a timber tree in Australia, and a booklet described its virtues as a possible source of hardwood. California's State Forester glowingly predicted: "It would appear that this State will become within the next twenty years the base of hardwood supply and the home of hardwood manufacturing. The new industry will produce a greater wealth than oranges."

Promoters jumped in by the score. They bought up big tracts of land at approximately $15 an acre, set out eucalyptus seedlings that cost them only $5 a thousand, and sold the land for $250 an acre, promising that within a decade the timber would be worth ten times that price. Modest proposals appeared in newspaper and magazine ads: "Put your surplus into eucalyptus and after ten years you can live on the income the rest of your life, and when you are gone your children and your children's children will . . . reap the same."

Lured by the same promise of perennially flowing wealth that caused Americans by the millions to invest in gold mines, real estate, and oil

wells, the eucalyptus boomers put cash on the line for title to a few acres planted with the magic new money tree. All over California the seedlings were set out in forests that filled canyons and covered hillsides and bottomlands. The excitement lasted about eight years. Then somebody made the embarrassing discovery that there was more than one kind of eucalyptus. There were, in fact, several hundred species in Australia. And the principal kind imported here, the blue gum, was not the species most commonly used in Australia for timber. Somebody might have yet imported the proper species and built up a thriving industry if it had not been for another disconcerting revelation: the trees used for timber in Australia did not produce the best timber until they were one hundred years old or more.

The hardy blue gum eucalyptus bears thousands of aromatic seedpods, which wind scatters for new growth.

One of 522 species is red-flowering eucalyptus. This symmetrical specimen stands before City Hall.

These magnificent trees thrive in Golden Gate Park, far enough apart to allow each enough light and soil.

Few investors were sufficiently patient. Furthermore, the eucalyptus boom was based on the assumption that eastern sources of hardwood would soon be exhausted; but they were not. So ended the great eucalyptus rush.

Yet the once-barren hills and valleys of California's lowlands are still clothed in thick forests —the overgrown remains of the big hardwood boom. And the trees have yielded scenic benefits quite apart from those expected by the planters. They have proved valuable for another reason: they intercept the summer fogs that roll in from the ocean. The moisture condenses on their leaves and drips to the ground like steady rainfall, building up the water table. Rain gauges in Berkeley have measured seasonal drip deposits of ten inches, equal to about half the normal annual rainfall for the area. Doubtless there is an equivalent effect in San Francisco's groves, particularly in Sutro Forest.

The fog-collecting capacity of the eucalyptus is partly a result of the same vertical foliage arrangement that gives the tree its reflective quality. The leaves, hanging loosely downward, present a barrier to the breeze-borne drops of fog vapor, which slide down the vertical leaf surfaces to the ground. Oddly, the juvenile leaves—on very young trees and new branches—are attached more rigidly, in conventional fashion. Then, at ages depending on the species and location, the leaves cease reaching upward for the sun and begin to hang down. Botanists puzzling over this peculiar change developed an explanation. In classic theory, in many species of both plants and animals the individual when young passes quickly through the same stages of evolution that the species went through over a period of thousands of years. Every high school biology student has been taught the formula: "Ontogeny recapitulates phylogeny." The history of the individual repeats the history of the species. According to this theory, at some time in the distant past in its native Australia, the eucalyptus lived in a temperate climate where moderate sunlight was interrupted by intervals of overcast or stormy weather. The leaves, like those of most other vegetation, reached upward and outward to maximize their exposure to the light.

Slowly, owing to little-known causes, the Australian climate began to change, becoming increasingly sunny and arid. Adapting to the new climate, the leaves slowly, over hundreds of generations, narrowed and began to hang vertically, turning the narrowest edge to the sun, and thus avoiding desiccation.

Recently, the recapitulation theory has been questioned. But, for whatever reason, the juvenile foliage is distinct from that of the adult tree. Look, for example, at Sutro Forest, where there has been little recent interference with natural processes. Here the prolific qualities of the eucalyptus are readily visible. The aromatic buds of the tree are thick underfoot, and young seedlings, with their primordial upreaching leaves, sprout wherever there is sufficient light and moisture. Many a sapling, like an adolescent with both childlike and grownup qualities, bears juvenile and adult foliage simultaneously.

Striking changes took place in the eucalyptus over the eons as it spread across parts of barren Australia, where there was little competition from other trees, and adapted itself to innumerable varying climates and terrains. The result was the development of some 522 species, most of which are unknown in California. But about 150 species have been introduced into this state. Of these, about two dozen are fairly common and supply endless variety to the city's eucalyptus landscapes.

There are two main groups—those that shed their bark and those that

Several species have odd-shaped leaves instead of typical long, narrow ones. Those of "shish kebab" appear to be impaled on a skewer.

Young silver-dollar eucalyptus has dollar-sized, silver-blue leaves. Sunlight provides backlight for the leaves, adding to silvery effect.

retain it the year round. The former are known to the unpoetic Australians simply as gum trees, owing to the gummy substance that flows out of the wood to heal a wound. Because of its rapid growth (the record is 75 feet in 10 years) the species of gum tree imported into California in greatest numbers is one whose name comes from the color of juvenile foliage—blue gum, *Eucalyptus globulus.* If you can't identify a eucalyptus, call it a blue gum, and chances are about nine out of ten you'll be right. It is notable for its height—this is the true "skyscraper eucalyptus," often exceeding 100 feet and sometimes approaching twice that height—and for aromatic pods that usually grow singly rather than in clusters, as do those of most other species.

The best-known blue gum in San Francisco is probably the spreading specimen in the middle of the Sixth Army Parade Ground in the Presidio, planted in 1876 in commemoration of the nation's centennial. The tallest eucalyptus trees in North America are in the grove of blue gums near the West Gate of the University of California campus in Berkeley. They were planted in 1877, are about 200 feet tall, and if transplanted to San Francisco's Union Square would tower over all the surrounding buildings. Near the campus grove, alongside the Life Sciences Building, is a superb example of *Eucalyptus viminalis,* known as manna gum or ribbon gum, from its habit of shedding bark in long dangling streamers. The underbark is often a striking cream color, and the species is sometimes called white eucalyptus. There are several dozen of these in the Panhandle of Golden Gate Park, along with the more numerous blue gum. Occasionally the foliage of *viminalis* grows in graceful pendent fashion, resembling that of the weeping willow. There are several of this weeping kind in San Francisco along Park-Presidio Boulevard.

Several species of eucalyptus have odd-shaped leaves, unlike the typical long, narrow, scythe-shaped leaves of the blue gum. The silver-dollar eucalyptus (*Eucalyptus polyanthemos*) has dollar-sized, silver-blue juvenile leaves, which develop into a pointed oval shape. Three of these trees can be seen near the 19th Avenue entrance to Golden Gate Park. The silver mountain gum (*Eucalyptus pulverulenta*) cannot be mistaken for any other species; its round, silver-gray leaves surround the stems like an order of shish kebab on a skewer. Several young "shish kebab" trees grow on the south side of Golden Gate Park's Main Drive.

There are two particularly notable eucalyptus trees in Golden Gate Park. One is a spreading, triple-trunked blue gum opposite the old "Crystal Palace" Conservatory. It is reputed to be the oldest tree in the park, planted by some unknown settler in the 1860's, the decade before the park was laid out. The other is the hauntingly exotic *Eucalyptus cinerea* growing south of the Main Drive in a big meadow just beyond the museum area. Its leaves are a shimmering silver-blue, and in certain slants of sunlight it seems scarcely real, standing uncertainly at the far edge of the meadow against a wall of conventional foliage like a wraith of a mirage—the quintessence of the city's eucalyptic splendor.

The bark of the manna gum tree peels in long strips revealing striking patterns and textures.

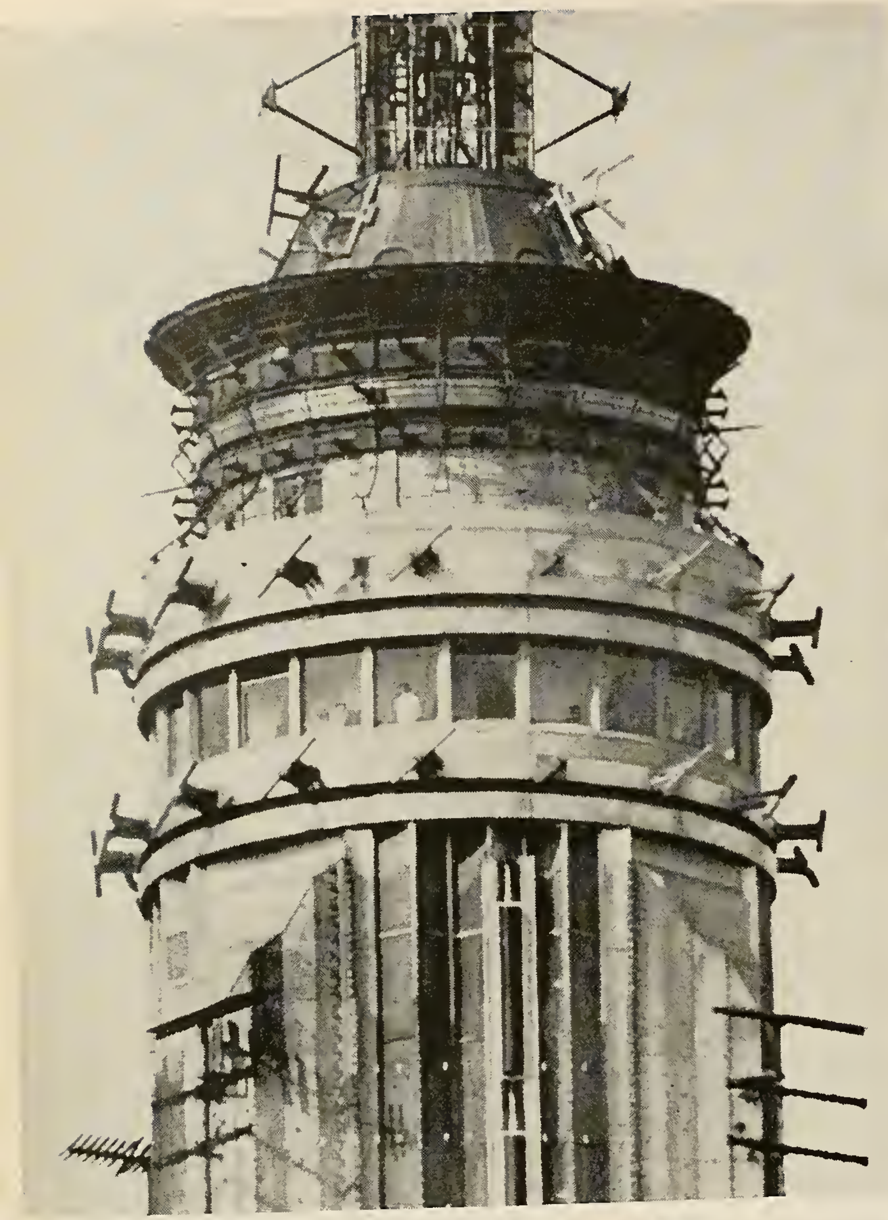
REVIEWS *continued from page 18*

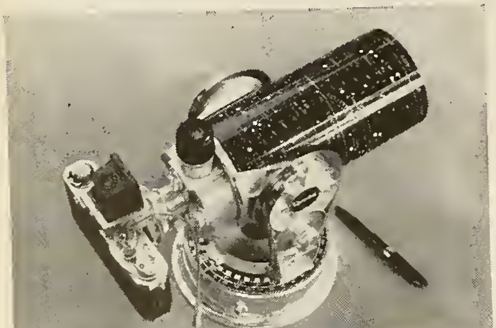
book. One is the term "innate schoolmarm" for hypothetical genetic agencies governing what the animal is to learn as it develops. Another is the "deprivation experiment," formerly the "isolation experiment," offered here as *the* method for determining what is innate. The author directs these ideas at the separation of innate and learned elements in behavior with a faith in their soundness hardly justified by evidence or comprehensive theory. The implication that the genes rigidly "program" the animal's learning is opposed by the results of many experiments, as well as by evidence from animal training. Under appropriate developmental conditions, animals do many things they never would do ordinarily. The deprivation experiment, widely used to study behavioral differences in young animals raised under conditions other than those presumed to be natural for them, is better termed change-of-environment test. Believing that "it can only tell us directly what is not learned," the author must assume that he knows beforehand the developmental significances of these "natural" conditions. This, however, is a major aspect of the problem under study. Actually, this method is only one of those now widely used in developmental research far wider in scope than is considered in *Behavior*.

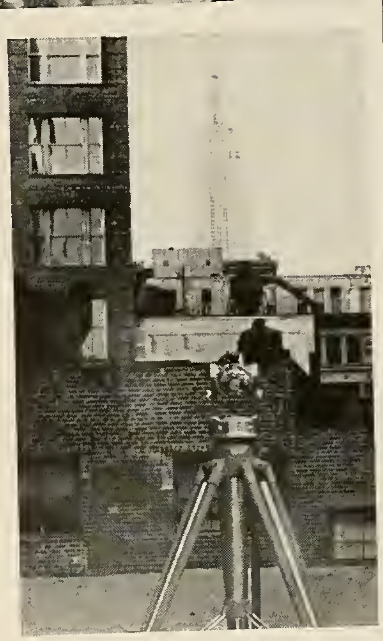
Lorenz' entire argument rests on the single assumption that patterns such as aggression are seated specifically in the genes. It is a long way from the genes to behavior, however, and the books under review do not light the path. This key assumption is not only unsupported, it is denied by a sizable weight of evidence. As is well known, the frequency and nature of aggression varies among members of both interspecies and intraspecies groups raised under conditions favorable to one or another pattern of behavioral development.

Lorenz seems interested neither in the study of individual differences nor in phyletic comparisons in behavioral development, yet these problems are vital to understanding how aggression, for example, arises and varies in different animals. The question of why, when two fish react to invasions of their territory, one flees whereas the other attacks, or why some people generally are peaceable whereas others are quarrelsome, is not easy. Neither is it the same question for fish and for people. All methods (including deprivation tests) must be used for studying such differences in function and in behavior throughout development.

The more scientists study behavioral development and its properties through the animal series, the less likely are they to follow Lorenz' oversimplified formula which he applies to all levels. As an example, in certain animals on







what I have called the "biosocial level," chemical secretions, according to concentrations, attract or repel species mates, thereby dominating behavior. Ants, bees, and wasps offer good examples of biological processes controlling behavior directly. On the "psychosocial level," in contrast, structural and physiological factors contribute indirectly to behavior and differently according to the conditions of individual development. In man, adrenalin—a neurosecretory, excitatory substance—arouses fighting, loving, poetizing, singing, or fleeing according to the individual's background and his current situation. The assumptions underlying the theory expounded in these books are open to question for lower animals; their extrapolation to man is doubtful.

It is as heavy a responsibility to inform man about aggressive tendencies assumed to be present on an inborn basis as it is to inform him about "original sin," which Lorenz admits in effect. A corollary risk is advising societies to base their programs of social training on attempts to inhibit hypothetical innate aggressions, instead of continuing positive measures for constructive behavior. Major aggressions of history, including Hitler's, may be attributed superficially to instincts or studied systematically with evidence known to historians and scientists.

For the past twenty years, Dr. Schneirla has been Curator in the Department of Animal Behavior, The American Museum.

THE WHOOPING CRANE: THE BIRD THAT DEFIES EXTINCTION, by Faith McNulty. *E. P. Dutton & Co., $4.95; 190 pp., illus.*

CRUSADES to save such magnificent birds as the Whooping Crane and California Condor symbolize the entire conservation movement. For this reason we find not only scientific treatises but also popular, even fictional, books about these and other extinct or threatened birds and mammals. Faith McNulty's book is written for the general reader, but it is far above the level of other efforts in this field, as regards both accuracy and wealth of detail. She has not romanticized, but lets the dramatic story speak for itself. She has had remarkable success in probing official and unofficial files and documents. Quotations from such sources provide fascinating reading, as we learn, for example, of the antics of a zoo keeper who was determined to keep a corner on the world's supply of captive Whooping Cranes, even though he lacked the personnel and equipment to care for them properly.

What of the future? The total number of Whooping Cranes has increased from a low of less than twenty to a present

total of fifty. But unless the population can be built up to at least three or four hundred, the fate of the species remains critical. A single hurricane or a drop in fertility, perhaps caused by inbreeding, could quickly undo the painfully slow progress of several decades. As the present book makes evident, there is much to be learned from past mistakes. Let us hope that those charged with the welfare of this bird may succeed until, like Colonel N. S. Goss, a pioneer Kansas naturalist, we may again thrill to the migrating whoopers as they follow "their leader in a wavy line, croaking as they go, like hounds upon a cold trail."

DEAN AMADON
The American Museum

MASKS, MUMMIES AND MAGICIANS, by Roger and Simone Waisbard. *Frederick A. Praeger, $5.95; 176 pp., illus.*

PUBLIC interest in New World archeology has increased remarkably in the course of the last ten years, and publishers have been eager to capitalize on that interest—so eager that they have marketed a good many bad books on the subject, as well as a few fine ones. One of the worst of the lot was a French entry, *La vie splendide des momies péruviennes*, which is now being offered to American readers in the form of a rather poor translation entitled *Masks, Mummies and Magicians.* It deals with the ancient history of the Rimac Valley of Peru, the valley in which the city of Lima is situated. The story that it tells is incoherent and untrustworthy. The authors, Simone and Roger Waisbard, have approached their task with great enthusiasm, but with considerable ineptitude.

The Waisbards are not archeologists; they do not even qualify as well-informed amateurs. It is obvious that on arriving in Lima a number of years ago, they were ill-equipped to undertake a job of archeological reporting. They knew virtually nothing about Peruvian prehistory and were unfamiliar with the methods and techniques of archeology. Nevertheless, after visiting a few excavations that were then under way, they became so fascinated by the Rimac Valley's pre-Hispanic past that they decided to write a book on the subject. They spent a good deal of time observing (although not actually participating in) Arturo Jiménez Borja's excavations at Pan de Azúcar and Puruchuco, and they delved into some early documents. There is no evidence, however, that they ever bothered to acquaint themselves with more than a tiny fraction of the pertinent archeological literature, and the small amount of it on which they did choose to rely served only to lead them seriously astray, for it introduced them to some highly conjectural and very shaky hypotheses, which they readily adopted as their own. What

he Waisbards have done, then, is to re-
gurgitate a mishmash of poorly digested
heories, most of which were only half-
baked to begin with. This unsavory mix-
ure has been lightly salted with "facts"
(a substantial proportion of which are
naccurate) and heavily peppered with
rrelevant digressions.

It is unfortunate that this book should
have been published in the first place. It
s downright amazing that it should
have been deemed worthy of translation
and that it should be inflicted on the U.S.
audience by the same publisher to whom
we are indebted for the American edition
of one of the best books on Central An-
dean archeology, G.H.S. Bushnell's
Peru. Anyone wishing to acquaint him-
self with the realities of Peruvian prehis-
ory would be well advised to avoid
Masks, Mummies and Magicians, for it is
packed with errors of every sort. He
should turn, instead, to Bushnell's *Peru*
(Praeger), to J. Alden Mason's *Ancient
Civilizations of Peru* (Pelican Books), or
o *Andean Culture History*, by Bennett
and Bird (an American Museum hand-
book).

Gary S. Vescelius
The American Museum

A Geography of China, by T. R. Tre-
gear. *Aldine Publishing Co., $7.95; 342
pp., illus.*

Here is a well-proportioned introduc-
tion to the anatomy of China, that
huge, but to Americans, vague entity,
which claims more and more of our at-
tention. After a sketch of the physical
geography—land forms, climate, and so
orth—Mr. Tregear proceeds to a half-
dozen historical problems amenable to
geographic analysis, then considers pop-
ulation problems and economic develop-
ment before and after 1949. The rest of
he book, except for a short concluding
chapter on "The Unity of China," treats
he country area by area. This regional
section is the best part of the work.

In the chapter on historical geogra-
phy, Mr. Tregear has done an excellent
job of selecting, as he says, "a few choice
plums" rather than attempting a con-
tinuous chronological presentation. But
is sources are less well chosen, and he
makes enough mistakes to destroy con-
fidence in the ideas he develops. Thus in
he section "Chinese Expansion and De-
elopment," he gives H. J. Wiens' *Chi-
na's March Toward the Tropics* as his
source for a series of population figures
hat show, as he says, "a more or less
static population over nearly 1,600
ears"—about 60 million from A.D. 2
until 1578. Hence "population pressures
appear to have had little to do" with the
millennial expansion of the Chinese
southward from their northern culture
hearth. But there are more careful esti-
mates of China's past populations than
Wiens': for example, Ping-ti Ho in his

Studies on the Population of China, 1368-1953 (which is listed in Mr. Tregear's bibliography) argues that the figure probably exceeded 100 million by the beginning of the twelfth century. Again, in the section "Chinese Origins," Mr. Tregear neglects recent studies (such as those of Chang Kwang-chih and Hermann von Wissmann), which would have enabled him to be much more precise, from the viewpoint of environment, about early differentiation into farming and herding societies.

The historical section, in particular, contains so many misleading statements and errors of fact that one must read it with great caution. For example, the well-field system (division of land into large squares composed of nine small ones, with the harvest of the middle one going to the feudal lord) is mentioned as if there were no question that it once existed. But if it did exist, it had broken down long before 221 B.C. Li Ping, author of the waterworks system of the Ch'eng-tu plain, was not active at about the same time as the Han Dynasty Emperor Wu, but two centuries earlier. Through most of the book, in fact, there are misprints and careless mistakes.

We have so few modern works on the geography of China that, despite these deficiencies, the geographer, as well as the general reader to whom Mr. Tregear hopes his book will appeal, will find it worth reading, particularly the regional descriptions. These are informative and relatively free from mistakes, and include a number of helpful maps and diagrams.

Andrew L. March
Columbia University

Eskimo Sculpture/Sculpture Esquimaude, by George Swinton. *McClelland and Stewart Limited (Toronto), $12.50; 224 pp., illus.*

George Swinton, the author of this beautifully made volume, states, "All this book wishes to accomplish is to plead for, and to effect, a more direct involvement with the art of living people." In demonstrating the use and significance of sculptural form in modern Eskimo carvings, however, Professor Swinton has given his work a broader scope. Many of the principles of art and cultural analysis suggested here might be applied to other areas of the world.

The book is made up of three main sections, the first a historical survey of Eskimo art. Following this, there is a fuller account of the development of the modern carving "industry" of eastern Canada, which has been a special interest of the author for some years. The final section contains pictures of the stone sculptures that have been made by the Eskimo in this area since 1949. Professor Swinton, of the University of Manitoba's

School of Fine Art, is himself an artist. He has selected over two hundred color and black-and-white plates to illustrate the esthetic quality achieved by the best carvings. Examples of typical themes are shown—hunting scenes, family groups, animals, and birds. A variety of treatments of each theme points out the possibility of local styles and variation by individuals. Although this material was made for sale to non-Eskimos, it still has the stamp of Eskimo traditions, giving it a unique art character.

In the text (which is bilingual), we may be grateful for Swinton's knowledgeable and enthusiastic approach. He has contributed much that will be of lasting interest to students and collectors of art, including the opportunity to follow the history of this art form from its earliest beginnings. The photographs, which are documented with the artist's name and village, are another unusual resource. The selected pieces show a vitality and convey a strength and directness that is peculiarly modern. They transmit something of the immediacy of Eskimo life; the artist's choice of subject matter reflects his vision of the world.

Eskimo Sculpture also points up the drama of the Eskimo as a culturally distinct group changing with the times. Art has its importance here, since "more than any other aspect of contemporary Eskimo life . . . [it] provides a link with the past." The Eskimo artist, while making necessary adjustments, still demonstrates through his art the hold that his traditional life has upon him.

PHILIP C. GIFFORD
The American Museum

New books about birds

POPULATION STUDIES OF BIRDS, by David Lack. Oxford University Press, $10.10; 341 pp., illus.

THE PARROTS OF AUSTRALIA, by William R. Eastman, Jr. and Alexander C. Hunt. Livingston Publishing Co., $12.50; 194 pp., illus.

THE SPECIES OF BIRDS OF SOUTH AMERICA, by Rodolphe Meyer De Schauensee with Eugene Eisenmann. Academy of Natural Sciences, $10.00; 577 pp.

THE BIRDS OF GUYANA, by Dorothy E. Snyder. The Peabody Museum, $6.00; 308 pp.

This list details the photographer, artist, or other source of illustrations, by page.

COVER—Lee Boltin
20-25—Michael Berrill except map, AMNH after Berrill
26—top, The Bettmann Archive; bottom, N.Y. Public Library
28-31—T. E. Eisner except 28—bottom left, AMNH after Eisner; 31—top, James S. Haeger
33-40—Lee Boltin
43-49—George Holton except map, AMNH after G. Reichel-Dolmatoff
50-51—top, Mount Wilson and Palomar Observatories; bottom, National Research Council except right, Courtesy of Peter M. Millman
52—National Research Council
53—AMNH
54-59—Michael Bry

Suggested Additional Reading

STILLNESS ON ENIWETOK

CORAL ISLAND. M. Bates and D. P. Abbott. Charles Scribner's Sons, New York, 1958.

ISLAND LIFE. S. Carlquist. Natural History Press, New York, 1965.

PROVING GROUND: AN ACCOUNT OF THE RADIOBIOLOGICAL STUDIES IN THE PACIFIC, 1946-1961. N. O. Hines. University of Washington Press, Seattle, 1962.

THE OCEAN ISLAND. G. Klingel. Anchor Books, Garden City, 1961.

THE ALLURE OF THE FEMALE MOSQUITO

COLONIZATION AND BIOLOGY OF OPIFEX FUSCUS. J. S. Haeger and M. W. Provost. *Transactions of the Royal Society of New Zealand*, Vol. 6, pages 21-31, 1965.

SWARMING AND MATING IN MOSQUITOES. E. T. Nielson and J. S. Haeger. *Miscellaneous Publications of the Entomological Society of America*, Vol. 1, No. 3, pages 71-95, 1960.

A STUDY OF MOSQUITO BEHAVIOR. L. M. Roth. *The American Midland Naturalist*, Vol. 40, pages 265-352. 1948.

ORIENTATION OF THE MALES OF AEDES AEGYPTI (L.) (DIPTERA; CULICIDAE) TO SOUND. G. Wishart, G. R. van Sickle, and D. F. Riordan. *The Canadian Entomologist*, Vol. 94, pages 614-626, 1962.

BASIL EDE'S BIRDS IN A NEW YORK GALLERY

THE ART OF FALCONRY, BEING THE DE ARTE VENANDI CUM AVIBUS OF FREDERICK II OF HOHENSTAUFEN. Translated and edited by C. A. Wood and F. M. Fyfe. Stanford University Press, 1943.

BIRD PORTRAITS IN COLOR. T. S. Roberts. University of Minnesota Press, Minneapolis, 1940.

JUNGLE GODS OF SAN AGUSTIN

ARCHAEOLOGICAL REGIONS OF COLOMBIA: A CERAMIC SURVEY. W. C. Bennet. *Yale University Publications in Anthropology*, No. 30, New Haven, 1944.

COLOMBIA. G. Reichel-Dolmatoff. Frederick A. Praeger, New York, 1965.

TREE OF LIGHT

THE EUCALYPTS: BOTANY, CULTIVATION, CHEMISTRY, AND UTILIZATION. A. R. Penfold and J. L. Willis. Interscience Publishers, New York, 1961.

EUCALYPTS FOR PLANTING. Food and Agricultural Organization, Forestry and Forest Products Studies #11, Rome, 1955.

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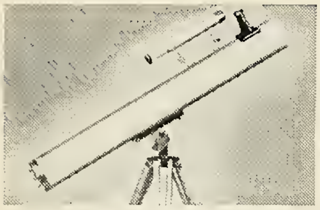

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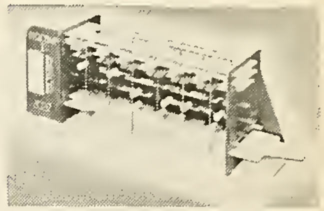

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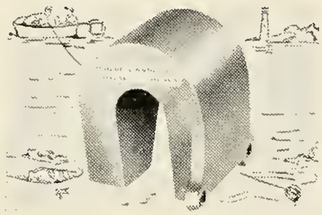

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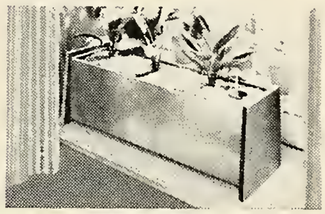

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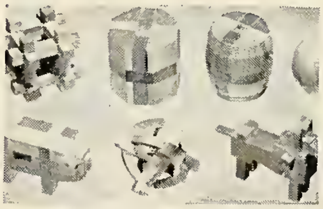

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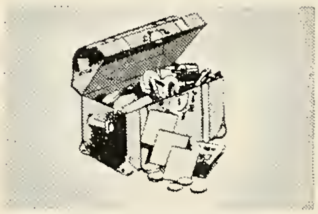

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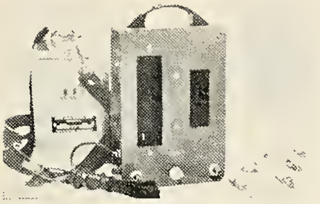

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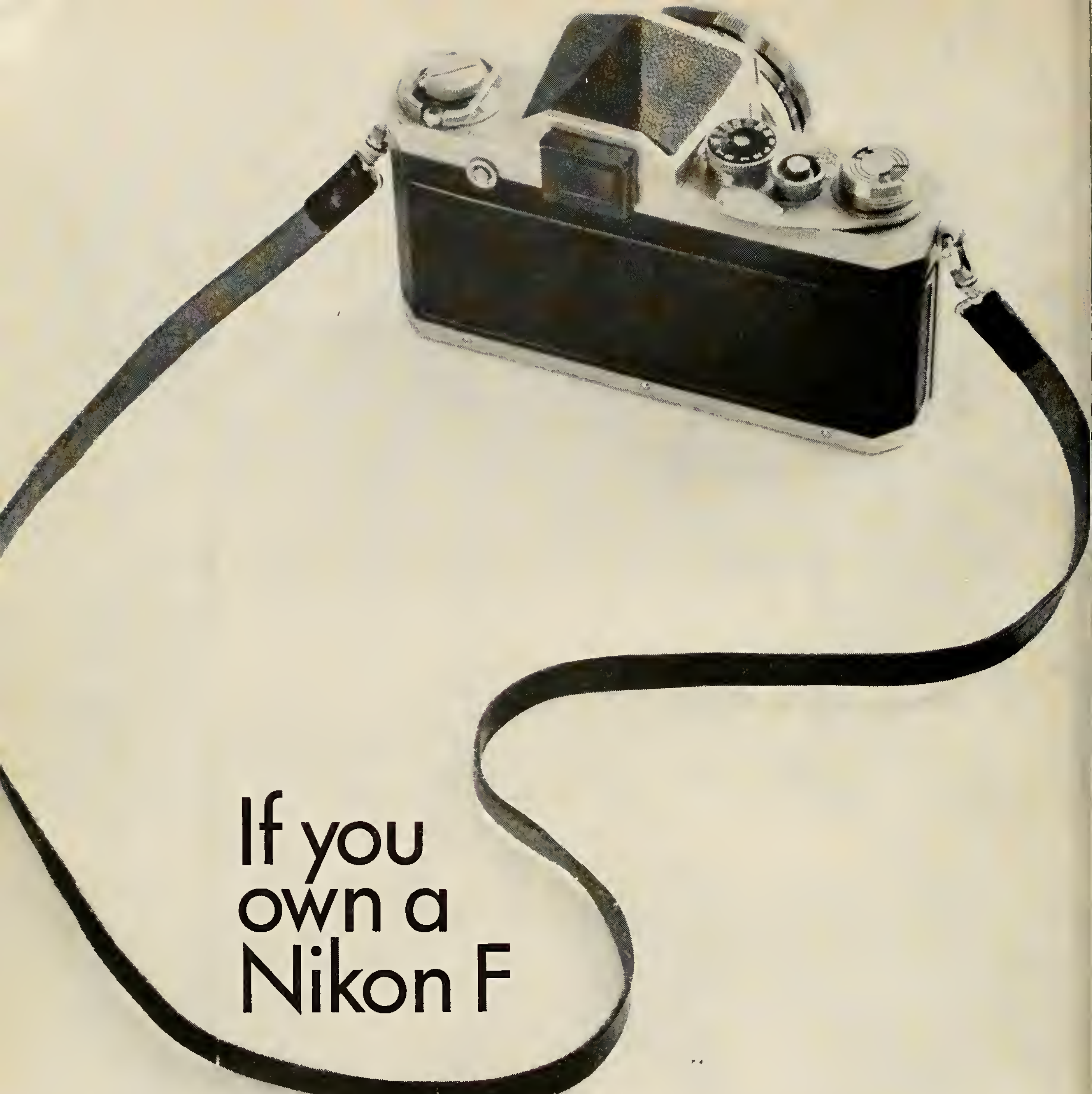

If you own a Nikon F

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You have all of this at your command, to draw upon and use, whether you
obtained your Nikon F today, yesterday or seven years ago.

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